TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

Number Ten

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Membership in the Society of Motion Picture Engineers stands for unselfish service to the Industry. Applications for membership are by invitation and endorsement. All checks should be made payable to the Society of Motion Picture Engineers.

All receipts are expended directly to promote the objects of the Society and the interests of its members. There are no salaries or emoluments of any kind.

The following are extracts from the By-Laws:

The objects of the Society are: The advancement in the theory and practice of motion-picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein and the maintenance of a high professional standing among its members.

An Active Member is one who is actually engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts, or who is interested directly in the art.

Any person of good character may be a member in any or all classes to which he is eligible.

Prospective members shall be proposed in writing by at least one member in good standing, and may be elected only by the unanimous vote of the Board of Governors.

All applications for membership or transfers in class shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

The entrance fee for all members shall be thirty-five dollars ($35.00). The annual dues shall be fifteen dollars ($15.00), payable in advance before the annual meeting (October) of each year. That is, the total fee for the first year which includes the entrance fees and first annual dues, is $50.00 for all members.

Motion Picture Standards Adopted in Committee of the Whole Society

The following have been adopted as standards by the Society of Motion-Picture Engineers, and are promulgated to encourage uniformity and standard practice throughout the Industry as a whole. Their early universal adoption will save the industry a great deal of present annoyance and monetary loss.

FILM SPEED—A film movement of sixty feet per minute through motion-picture mechanisms shall be considered as standard speed.

FILM PERFORATION—The dimensions and location of film perforation shall be in accord with the illustrating diagram herewith.

FRAME LINE—The dividing line between pictures on motion-picture film shall lie exactly midway between the marginal perforations.

INTERMITTENT GEAR RATIO—The movement of the intermittent gear shall be expressed in degrees of rotation during which the pin of the driver is in contact with the slot of the driven gear. For example, a gear in which the pin is engaged with the slot for one-quarter of a revolution of the driver shall be called a 90-degree movement; that in which the pin is engaged with the slot for one-sixth of a revolution shall be called a 60-degree movement, etc.

LANTERN SLIDE MAT OPENING—A standard opening in mats of lantern slides for use in conjunction with motion pictures shall be 3 inches wide by 2¼ inches high.

THUMB MARK—The thumb mark spot on a lantern slide shall be located in the lower left hand corner next the reader when the slide is held so as to be read against a light.

LANTERN STRIP—A red binding strip to be used on the lower edge of the lantern slide.

PICTURE APERTURE—The standard film picture aperture in a projecting machine shall be 0.906 inch wide and 0.6795 inch high, namely, 29/32″ and 87/128″.

PROJECTION ANGLE—The maximum permissible angle in picture projection shall not exceed twelve degrees (12°) from a perpendicular to the screen surface.

PROJECTION LENS FOCI—The focus of motion-picture projection lenses shall increase in ¼″ steps to 8 inches and from 8 to 9 in ½-inch steps.

PROJECTION LENS MOUNTING—Picture projecting lenses shall be so mounted that the light from the film picture aperture shall have an uninterrupted full path to the rear component of the lens.

PROJECTING LENS HEIGHT—The standard height from the door to the center of the projecting lens of a motion picture machine shall be 48 inches.

PROJECTION LENS OPENING—The diameter of unit opening for projecting lens holder shall be 1 15/16 inch.

PROJECTION OBJECTIVES—Shall have the equivalent focal length marked thereon in inches and quarters and halves of an inch, in decimals, with a plus (+) or minus (—) tolerance not to exceed 1 per cent of the designated equivalent focal length also marked by the proper sign following the figure.

REEL—The approved standard reel shall be 10 inches in diameter; 1½ inches inside width; with 5/16-inch center hole, with a key-way ⅛" by ⅛" extending all the way through; a 2-inch hub; and a permissible flange wabble of not more than 1/16-inch.

STANDARD PICTURE FILM—Shall be one and one-third inches wide, and carry a picture for each four perforations, the vertical position of the picture being longitudinal of the film.

STANDARD REEL FILM—Shall have black film leaders, with tinted (red, green or blue) trailers; should have marking thereon embossed rather than punched in the film; and each reel of a multiple-reel story should end with a title, and the next reel begin with the same title.

TAKE-UP PULL—The take-up pull on film shall not exceed 15 ounces at the periphery of a 10-inch reel or 16 ounces on a (11-inch) reel.

STANDARD NON-INFLAMMABLE FILM—Standard adopted for approved non-inflammable film is illustrated in the diagram below:

Motion-Picture Nomenclature

SOCIETY OF MOTION-PICTURE ENGINEERS

Adopted as Amended in Committee of the Whole, as Recommended in the Report of Nomenclature Committee.

Rules which Governed the Committee in its Recommendations

It was believed that—

(1) The Committee should give to words used in older arts and industries, their previous accepted meaning.

(2) Definitions of words should be selected which define their meaning rather than explain uses.

(3) Definitions should be as short as consistent with unquestionable identification.

(4) Definitions should not be included in the list which are so self-evident or of such wide use as to make our work seem cumbersome and trifling.

And that the following three classes of words only be defined:

(1) Expressions belonging to the projection industry alone, the meaning of which has long been accepted by the whole industry.

(2) Expressions from other industries used universally in motion-picture work, with specialized meanings.

(3) Expressions the meaning of which may be difficult to find in ordinary reference books or which are already used in more than one way in other industries.

ACTION—The director's command to the players to begin performing.

BACK FOCUS—Properly called working distance.

BUSINESS—Action by the player; e. g., business of shutting door.

BUST—A small, magnified part of a large scene.

CAMERA—An expression used to command the photographer to begin taking the scene.

CHANGE OVER—The stopping of one projecting machine and the simultaneous starting of a second machine in order to maintain an uninterrupted picture on the screen when showing a multiple-reel story.

CINE—A prefix used in description of the motion-picture art or apparatus.

CLOSE-UP—Scene or action taken with the character close to the camera.

CONDENSERS—The lens combination which deflects the diverging rays of the luminant into the objective.

Collector Lens—The lens next to the source of light.

Converging Lens—The lens nearest the objective.

Middle Lens—Of a three-lens combination, the lens lying between the collector lens and the converging lens.

CUTTING—Editing a picture by elimination of useless or unacceptable film.

CUT-BACK—Scenes which are returns to previous action.

CUT-IN—Anything inserted in a scene which breaks its continuity.

DEVELOPING—Making visible the latent image in an exposed film.

DISSOLVE—The gradual transition of one scene into another.

DIRECTOR—The person who directs the actual production of the photoplay.

DOUBLE EXPOSURE—The exposure of a negative film in a camera twice before development.

DOUBLE PRINTING—The exposure of a sensitive film under two negatives prior to development.

DOUSER—The manually operated door in the projecting machine which intercepts the light before it reaches the film.

DUPE—A negative made from a positive.

EFFECTIVE APERTURE—The largest diameter of a lens available under the conditions considered.

EQUIVALENT FOCUS—The equivalent focus of a plurality of lenses in combination is the focal length of a simple thin lens which will under all conditions form an image having the same magnification as will the given lens combination.

EXTERIOR—A scene supposed to be taken out of doors.

FADE-IN—The gradual appearance of the picture from darkness to full screen brilliancy.

FADE-OUT—The gradual disappearance of the screen-picture into blackness. (The reverse of fade-in).

FEATURE—A pictured story, a plurality of reels in length.

FIXING—Making permanent the developed image in a film.

FLAT—A bit of painted canvas, or the like.

FLASH—A short scene, usually not more than three to five feet of film.

FLASH-BACK—A very short cut-back.

FOOTAGE—Film length measured in feet.

FRAME (verb)—To bring a frame into register with the aperture during the period of rest.

FRAME (noun)—A single picture of the series on a motion-picture film.

FRAME LINE—The dividing line between two frames.

INTERMITTENT SPROCKET—The sprocket which engages the film to give it intermittent movement at the picture aperture.

IRIS—An adjustable lens diaphragm.

IRISING—Gradually narrowing the field of vision by a mechanical device on the camera.

INSERT—Any photographic matter, without action, in the film.

INTERIOR—Any scene supposed to be taken inside a building.

JOINING—Splicing into a continuous strip (usually 1,000 feet) the separate scenes, titles, etc., of a picture.

LANTERN PICTURE—A still picture projected on a screen by means of an optical lantern or stereopticon.

LANTERN SLIDE (see slide)—The transparent picture from which a lantern picture is projected.

LEADERS—That piece of blank film attached to the beginning of the picture series.

LIGHT BEAM—A bundle of light rays.

LIGHT RAY—A thin line of light.

LOCATION—Any place selected for the action of an outdoor scene.

MAGAZINE VALVE—The film opening in the magazine of a motion-picture projector.

MASKS—Opaque plates of various sizes and shapes used in the camera to protect parts of the negative from exposure.

MOTION-PICTURE—The synthesis of a series of related picture elements, usually of an object in motion.

MOTION-PICTURE FILM—The ribbon upon which the series of related picture elements is recorded.

MOTION-PICTURE PROJECTOR—An optical lantern equipped with mechanisms for suitably moving motion-picture film across the projected light.

MOVIES—Motion pictures.

MULTIPLE-REEL—A photoplay of more than a thousand feet of film in length.

NEGATIVE—The developed film, after being exposed in a camera.

NEGATIVE STOCK—Light sensitive film intended for motion-picture camera use.

OBJECTIVE—The picture-forming member (lens) of the optical system.

OPTIENCE—A collection of persons assembled to see motion pictures.

PAM—Contraction for panorama.

PANORAM—The act of, or device for, turning a motion-picture camera horizontally, to photograph a moving object, or to embrace a wide angle of view.

PHOTOPLAY—A story in motion pictures.

POSITIVE—The developed film, after being printed through a negative.

POSITIVE STOCK—The light-sensitive film intended to be printed upon through a negative.

PRE-RELEASE—A picture not yet released for public showing.

PRINT—Same as "positive."

PRODUCER—The maker of photoplays.

PROGRAM—The complete show for a single optience.

PROPS—Contraction of properties. Objects used as accessories in a play.

PROJECTION DISTANCE—The distance between the objective and the screen of a stereopticon lantern or motion-picture projecting machine.

PROJECTING LENS—Properly called projection objective.

PROJECTION OBJECTIVE—The objective which forms an image of the lantern slide or film, upon the screen.

REEL—The flanged spool upon which film is wound for use in projecting machines.

REEL—An arbitrary unit of linear measure for film—approximately a thousand feet.

REGISTER—A term denoting facial expression of emotions.

RELEASE—The publication of a photoplay.

RETAKE—Rephotographing a scene.

REWIND—The process of reversing the winding of a film, usually so that the end to be first projected shall lie on the outside of the roll.

REWINDER—The mechanism by which rewinding is accomplished.

SCENE—The action taken at a single camera setting.

SCENARIO—A general description of the action of a proposed photoplay.

SCREEN—The surface upon which a picture is optically projected.

SHOOTING A SCENE—Photographing the scene.

SHUTTER—The obscuring device, usually a revolving segmental disc, employed to intercept the light during the movement of the film in motion-picture apparatus.

Shutter—Working blade—(also variously known as the cutting blade, obscuring blade, main blade, master blade or travel blade). That segment which intercepts the light during the movement of the film at the picture aperture.

Shutter—Intercepting blade—(also known as the flicker blade). That segment which intercepts the light one or more times during the rest or projection period of the film to eliminate flicker.

SINGLE PICTURE CRANK (sometimes referred to as trick spindle)—That spindle and crank on a motion-picture camera which makes one exposure at each complete revolution.

SLIDE (Stereo slide)—The transparent picture from which a screen still is projected.

SPLICING—Joining the ends of film by cementing.

SPLIT REEL—A reel having two or more picture subjects thereon.

SPOT—The illuminated area on the aperture plate of a motion-picture projector.

SPROCKET—The revolvable toothed member which engages the perforations in the film.

STEREOPTICON—A lantern for projecting transparent pictures, i. e., lantern slides, often a double lantern for dissolving.

STILL—A picture from a single negative.

TAKE-UP (noun)—The mechanism which receives and winds the film after it passes the picture aperture.

TAKE-UP (verb)—Winding up the film after it passes the picture aperture.

THROW—Projection distance.

TILT—The act of, or device for, moving a camera vertically while in use.

TINTING—Coloring a film by dyeing the gelatine side of it.

TONING—Coloring a film by chemical action on the silver image.

TRICK CRANK—A camera crank giving a single exposure for each turn.

TRICK-PICTURE—A picture in which unnatural action appears.

TRAILER—That piece of blank film attached to the end of a picture series.

VISION—A new subject introduced into the main picture, by the gradual fading-in and fading-out of the new subject, as, for example, to visualize a thought.

WORKING DISTANCE—The distance from the principal focus of a lens to its nearest face; e. g., the distance from the slide or film to the nearest lens of the objective.

Remote Control Switchboards for Motion-Picture Studios

By H. A. MacNary

In papers presented to the Society of Motion-Picture Engineers on the various phases of studio lighting, the great need for flexibility in the lighting facilities has been well covered. For this reason, it is felt to be unnecessary to go into the arguments for flexible operation. The able papers presented by Messrs. Mayer and Allison will be found to cover this subject in a comprehensive manner.

Nearly all of the studios at the present time are equipped with the wall pocket method. A brief outline of this is as follows at given distances usually every 20 to 30 feet around the wall of the studio stage there are wall pockets of usually 100-amp. size either 2 or 3 wire, depending upon the character of the supply. These wall pockets are controlled from a stage switchboard which is usually made up as follows. There is a double set of bus on the back of the board one that is always alive and the other dead or alive, depending upon the position of the master switch. Each and every wall pocket is connected to the middle point of a double-throw knife switch either 2 or 3 pole, the one side is connected to the live bus, the other side connected to bus controlled by the master switch. This gives a flexible outfit because any light effect can be made by placing all lights to come off at one time on the master switch. It is common practice to have not more than six switches to each master. Take a large studio where there may be 6 to 8 companies working and imagine the confusion when a number of electricians are signalling for light effects all at the same time. Also the mass of cable strewn on the floor because all the cables must come from these wall pockets.

Fig. 1. A Typical Studio Scene When Remote Control is Not Used.

The above is a typical example of cable strewn on studio floor. This not only hinders stage workers in moving props, but also shortens the life of cable by being cut and destroyed by people walking and dragging lamps and apparatus over it. These are a few of the reasons for remote control.

By remote control switchboards for moving-picture studios we mean a board made up of contactors instead of switches, a switchboard that can be operated from a point far distant from the switchboard itself, thus eliminating the necessity of signalling by electricians or by telephone or enunciators. The remote control is an overhead scheme and this also gets rid of cable all over the floor. This will be seen later as the remote control system is described.

In a small studio, where there are only one or two companies to work, one to two remote control boxes would be used; probably one box to each company. They would be mounted overhead, either on the wall or on runway. The following diagram represents a typical installation. Boxes will be lettered A, B, etc., and so on depending upon the number in each of the boxes which will be described in detail later as 4 or 6 Kliegl receptacle and plugs 100 amp. capacity, either two or three wire. For this example we will use two boxes, A and B, using 6 Kliegl 3 wire receptacles and plugs. The remote control contactor boxes would be mounted overhead on runways; these would each have its separate feed coming from a small feeder board having a 600-amp. fused switch for each box.

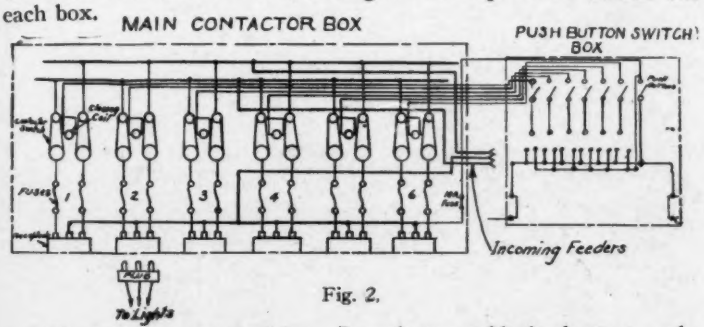


Fig. 2.

From this contactor box a 7-conductor cable leads to a push-button station. This push-button station is portable and may be carried to any part of the studio floor.

DESCRIPTION OF CONTACTOR BOX

We will take the whole system and describe each separate part, first the contactor box. The contactor box is made up in 4, 6 and 8 outlet sizes, with either removable back or top. It is made of 10-gauge sheet iron. We will describe in detail a six-outlet box. The box is 60 inches long, 30 inches wide and 20 inches deep; along the bottom equally spaced are 6 Kliegl 3-wire, 100-amp. receptacles into which cables from the stage spiders are plugged. At first these cables were entered directly into the receptacles but a recent

improvement in the box comprises an eye-bolt, which assumes the weight of the cables and removes all tension from the plugs and receptacles.

Directly above the tops of the receptacles and a little to the rear is suspended the neutral or middle leg of the three-wire system. The middle points of all receptacles are connected to this leg. One point of this bus bar is a connector to which the main incoming feed is connected. Directly above this middle or neutral leg is a slate panel 9 x 60 x 1¼. This panel is held in place by being bolted to a 2 x 2-inch angle which runs from top to bottom of the contactor box. On this slate are mounted twelve 100-amp., 250-volt enclosed fuses and fuse holders. The two outside points of the receptacles are connected to these fuses.

Above this panel is another slate panel, 12 x 60 x 1¼. On this panel are mounted the six two-pole 125-ampere contactors. Behind these contactors are suspended the other two legs of the three-wire

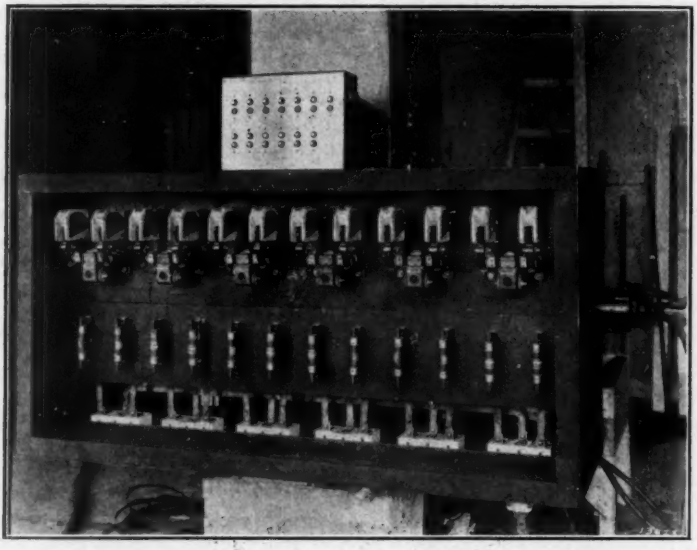


Fig. 3.

systems. One leg goes to one pole of the contactor and the other leg to the remaining pole. The circuit is completed by connecting the other side of the two-pole contactor to the top side of the fuses directly underneath. The contactors are light, being made of pressed steel. They are the back connected type fitted with blow-out coils which has proved to be a valuable feature for studio work because of the high inductive load usually encountered. The contactors are closed against the action of a spring by means of a

coil with an iron core acting as a magnet. One side of the coil is connected to the positive leg of the three-wire system and the other side is brought out to one side of the box to the female portion of a train line connector. This accounts for six of the leads. The seventh is brought from the neutral leg to the same train line connector.

Description of Push-Button Station

The male portion of the train line connector just referred to connects to the seven-conductor flexible cable leading to the push-button station located wherever necessary.

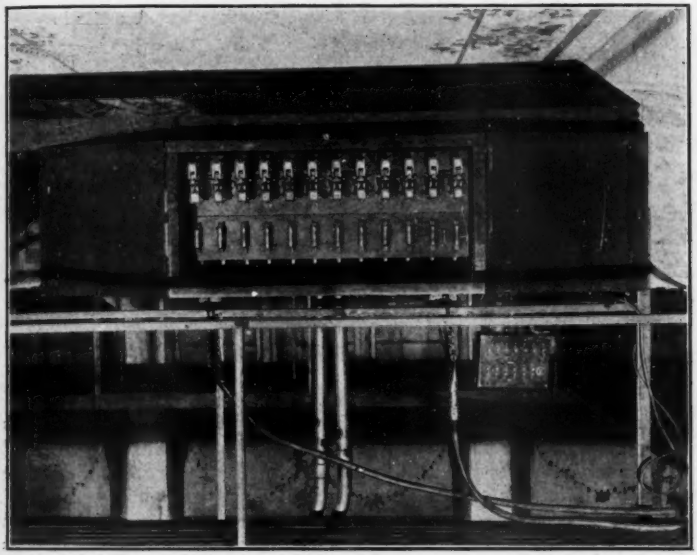


Fig. 4.

These push-button stations are small sheet-iron boxes, 16 x 10 x 6. The cover is a brass gang plate accommodating 13 push buttons, seven in the top row and 6 in the lower row. On one side of the box is a handle to simplify carrying.

The type of push-button station now in use is as follows: The top row of push buttons are of the ordinary house type, "on" and "off." These are numbered 1, 2, 3, etc., up to six. The seventh button is labeled "Master." The lower row of buttons are of the "three-way" type. One side of the "on" and "off" buttons is connected to binding-posts on the outside of the box numbered to correspond to the number of the button from which it comes. The other side is connected to the middle point of the three-point buttons.

Of the two remaining points of the three-way buttons one terminal of each is connected to a common wire which in turn is connected to the "off" side of the "Master" button. The third and last point of each button is connected to a common wire which leads to the live side of the "on" and "off" "Master" button. The live side of the "Master" button is connected to the seventh binding-post on the outside of the box. The numbers on the binding-posts must be connected to the corresponding number on the contactor box.

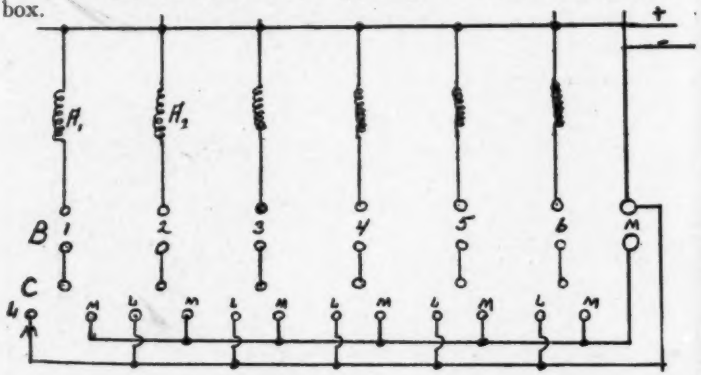


Fig. 5.

How the System Operates

In this diagram the line across the top is the positive side of the line, the coils lettered A_1, A_2, and so on to A_6, are the shunt coils of the contactor. The letters *B*, 1, 2, 3, and up to the one marked *M* are the ordinary on and off push-buttons and correspond to the top row of buttons on the push-button station; the three-point button labelled *C* is the bottom row of buttons on the push-button station and the side labelled *L* jumps the Master button and goes to the live side of the Master button; the live side of the Master button is connected to the negative or to the neutral wire, depending on whether the coil of the contactor is for 115 or 230 volts. The side of the button labelled *M* goes to the off side of the Master button and is therefore controlled by it.

Perhaps the easiest way to follow the working of the apparatus is to take a definite example such as the studio electrician is apt to run across. We will assume that he has a set that will require the use of all six contactors and also that he wants to cut off a number of lights at one time for an effect we will say the lights to come off will be placed on contactors 1, 3, and 6 and at a later time in the set he wants to take off all the lights connected to contactors 2 and 4. The first thing he does is to throw the main feed switch for the contactor box; next he puts in the stage plugs in the bottom of the contactor box, carries the cables with the

spider boxes along the runway and drops the spiders down to the studio stage alongside of the set just where they are needed and plugs in his lamps. He now takes his push-button station and plugs that in the contactor box and drops this down to the floor right next to the director and camera man. The electrician knows what lights are on each contactor and he has the effect as stated above. He now adjusts the push-button box, like the following diagram; that is, he closes the one and off buttons numbers 1, 3 and 6, and then that is all he has to do to the upper row until he is ready to shoot the picture. In the bottom row he throws the buttons of 1, 3 and 6 to the side marked "Master" and the buttons marked

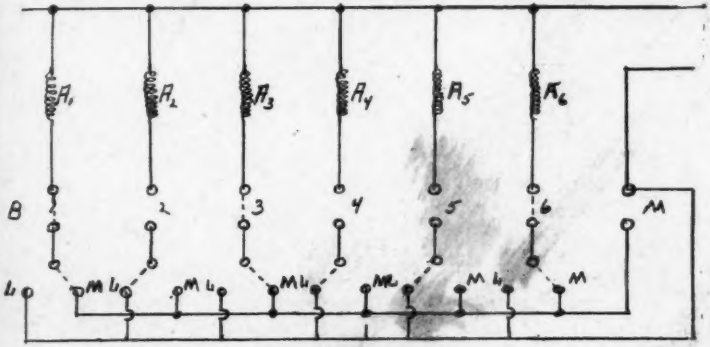


Fig. 6.

2, 4 and 5 are pushed into the side marked "line." The set is now ready for operation. Let us follow through all of the connections and we will find that there are no lights on.

The director now calls for lights. The electrician now closes the Master button and if you will follow through connections you will find that this closes contactors 1, 3 and 6, which gives lights that are connected to these contactors. He now pushes buttons marked 2, 4 and 5 to the "on" position and this gives all the lights on the set. He receives his cue to take off lights that are on the contactors 1, 3 and 6. He does this by simply pushing the Master button into the "off" position; the set continues and the electrician gets his cue to take off another bunch of lights and, as we assumed that these were on contactors 2 and 4, the electrician has two ways that he can do this. The first way is to push both buttons in the upper row marked 2 and 4 to the "off" position. The other way is as follows: After he has taken off his first light effect has pushed his "on" and "off" buttons of contactors 1, 3 and 6 to the "off" position, closed the Master button and switched the three-way buttons of 2 and 4 to the Master side, he then can control these by means of his Master button. This operation cannot always be done, since when the electrician changes from the line side of the three-way button to the master side he puts the lights out and then on again.

Before telling of some of the installations of this system it might be well to describe in detail the type of contactors used. In all of the installations up to the present time the contactor used is the single-pole 125-ampere with the shunt coils connected in parallel to make each two-pole contactor. The frame of the contactor is of pressed steel to make contactor very light and yet rugged. Contactors are equipped with blow-out coils in order to keep the contact surfaces clean. This is accomplished by means of a magnetic blow-out which forces the arc away from the surfaces carrying the current. This action is still further improved by use of rolling contacts. The rolling contacts have been recognized for years as the best form of contact. Some of the advantages of the rolling contacts are as follows:

1. The current is carried at the heel of the contact which is subjected to the maximum spring pressure and is kept clean by a slight sliding motion during the closing. period.
2. The arcing takes place at the tip of the contact as this is the last part of the contact to separate.
3. The rolling action minimizes the bounce when closing.
4. Little chance for the contacts to become welded when together. The slight bounce which is always present when the contacts are brought together with any speed causes a slight arc to be drawn during the closing of the contact. With the rolling contact, the surfaces are quickly shifted from the tip to the heel under a very powerful leverage action, so that there is little opportunity for the arc to weld the contact together.

INSTALLATIONS

To the writer's knowledge there are only two installations of the remote control system in the studios of this country at the present time and both of these are the same as the one above described.

The first one installed and working was that in the Amsterdam studios in New York owned by A. J. Bimberg but rented to the Famous Players-Lasky Corp. This studio was an old opera house and was only recently remodelled into a studio.

The main stage is approximately 100 feet long and about 50 feet wide; it runs east and west. Along the west wall evenly spaced are three contactor boxes, each box containing four contactors. These boxes are mounted on the wall about 25 feet from the floor and they are reached by means of the overhead runways. This studio has three runways about 6 feet from the ceiling running the length of the stage with a number of cross runways in between. The push-button stations in the studio are permanently connected to the contactor boxes by means of 100 feet of the seven-conductor cable.

INTERNATIONAL STUDIO

This studio was an old dance hall until a very short time ago and then was turned into a studio. From these pictures you can

easily see the overhead runways and some of the remote control switchboards. In this studio on the first balcony is mounted the main feeder panel. From the Edison incoming line two feeds are run up to this feeder board. The feeder board is a three-panel type having two 600-ampere knife switches on each panel. Each one of these switches feeds to one of the contactor boxes. The push-button stations in this studio are similar to those described before

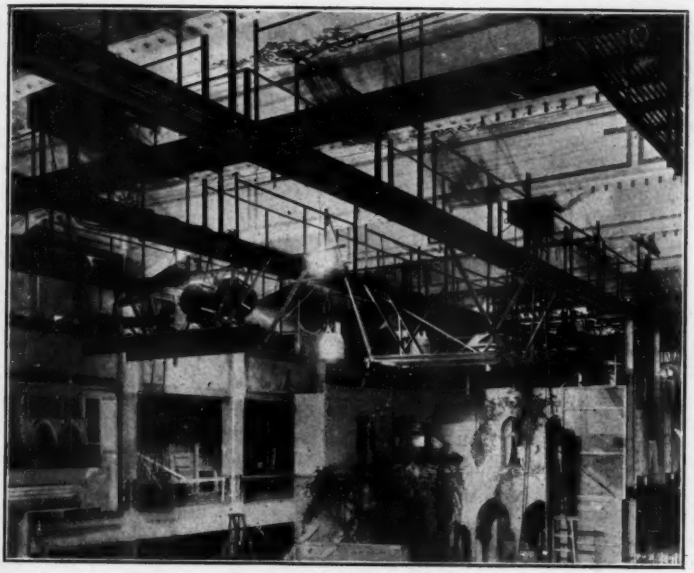


Fig. 7.

and differ from the other installation as follows: They have a train line receptacle, which means that the push-button station can be removed from the contactor box at will; also it is equipped with a jumper connecting the "off" side of the Master button of one station to the "off" side of the Master buttons of two other stations. By means of this one can readily see that one Master button could control every button on the six push buttons, which means that the 36 contactors could be closed or opened at one time simply by pushing one Master button.

These are the only two installations of any kind of remote control that are in operation at the present time, although the Metro studio in Hollywood is now planning a system very similar to the one described above and the Fox studios in New York will have one in a short time that is vastly different from this and the Famous Players-Lasky in their new studio will have a remote control system that is also different.

Perhaps at some future meeting one of the above installations, or perhaps both, could be presented in a paper that would be of great interest to the Society.

Papers Committee Report

By L. C. Porter

Gentlemen:

An engineering society such as ours is of use first to its members; next to the industry they represent; third to the public in general, largely in proportion to the amount of data that is collected, analyzed and exchanged through the mediums of convention papers, committee meetings and personal contact. Such data forms the basis of standardization, of practice and equipment, as well as development and progress.

Success along these lines means that our organization will take its place among leading engineering societies of the country, thereby becoming a powerful factor in the standardization and growth of the motion picture industry.

Your papers committee, whose privilege it is to have most to do with the securing and presenting data in the form of papers and committee reports, has felt a very keen responsibility in their work. While the results have not been entirely satisfactory to the committee and may not be to the society, we have worked hard and offer no apologies, but earnestly solicit constructive criticism and welcome suggestions on which we can act in the future.

It may be worth while to take the time to point out to you the general line of procedure which we have followed in preparing for this convention.

First: In order that the different members of the committee should not unnecessarily duplicate work a tentative program was laid out last November and different members of the committee assigned specific things to do as follows:

1. To classify the Society membership into the various branches of the industry and find out how many, if any, papers have been contributed pertaining to each branch and to make special effort to get papers on the branches having few. This classification appeared in the Pittsburgh Transactions.

2. To send a letter to the entire membership requesting them to express their preference as to subjects and authors for convention papers. This was done, but received little response.

3. To keep the membership posted from time to time as to the nature and amount of material being secured for the Montreal Convention. This was accomplished through multigraph copies of the papers committee's monthly progress report sent out by our society.

4. To study the transactions of the engineering organizations whose work overlaps that of our society, such as the Illuminating Engineering Society, and secure a resumé of papers presented before such other organizations as have a bearing on our work.

Also to get in touch with such societies and the authors of such papers with a view of securing joint papers or at least an exchange of speakers.

Unfortunately, pressure of business has prevented this work from being done. It is the hope of the papers committee to have the work taken up by someone who will have the time to carry it through.

5. To make a study of the possibilities of securing such papers as would contribute to a possible educational course. This work has been outlined to you as suggestions in connection with the report of the Educational Committee.

6. To form a new committee known as the Progress Committee whose work would be to review and report the advance of the entire art since the last convention. The very interesting report of this committee testifies to its success.

7. To prepare a definite program time schedule for the convention, grouping papers and committee reports bearing on similar topics.

8. To leave no stone unturned in securing papers that we believe desirable.

In carrying out the last work the committee has used approximately fifteen pounds of stationery, representing two thousand sheets, 8 by 10 inches, typewritten material, the majority of which is composed of dictated letters.

Nomenclature lists and the society pamphlet "Notes on the Preparation of Papers and Discussions" were sent to all prospective authors.

An effort was made to secure synopses of the various papers considerably in advance of the text. These synopses were turned over to the trade papers as fast as they were received.

Advance copies of some of the papers were prepared and sent to those requesting them and a return postal card sent to the entire membership. The only reason that advance copies of all the papers were not available is because the papers committee did not receive the texts in time. In fact, some of the papers have not yet been turned in. If they are to appear in the *Transactions,* they must be received in the very near future as we shall try and send the *Transactions* to press June 1st. The various papers are being edited for appearance in the *Transactions.* In this work no changes are made in the fundamental data or text, but the phraseology and terminology are being dressed up to conform to our recognized nomenclature and to be suited to the dignified transactions of an engineering body.

We have been unable to accept several proposed papers on account of an overflowing program. It is our hope that the authors of these papers will re-submit them in ample time for the Fall convention and that the members of the Society will assist the papers committee by personal efforts to put us in touch with men who are doing interesting work of value to our membership and worthy

of consideration for presentation to this society as a convention paper.

It is the earnest recommendation of the papers committee that in the future, individual discussions of the papers be strictly limited to four minutes. We believe that the meat of any discussion can be presented in such time. The rest of it, if desired, can be submitted in writing for use in the *Transactions*.

We also urge that stenographic reports of these four-minute discussions be taken down, edited and printed with the paper in the *Transactions*.

Supplement to Report of Papers Committee

Educational Suggestions

In considering past activities, present program and the future policy of the Papers Committee, the members of this committee have many times discussed the advisability of a complete educational program for the projectionist. With the diversified program which has been arranged for this convention, it seemed the proper time to suggest the consideration of such educational activities of the Society.

The National Electric Light Association, which is an association of all the large electrical illuminating companies in the country, has prepared a correspondence course for the education of the illuminating companies' employees. This correspondence course is sold to the employees and has met with great success, both in the results obtained, and the financial return to the association. It is the suggestion of your Papers Committee that a similar idea be carried out by this Society for the purpose of bringing before the projectionist in lessons the combined knowledge of the experts of the various lines represented in our Society. There are several handbooks available for the projectionist but none of them are in educational form.

It is the suggestion of your Papers Committee that in the future as many papers as possible be presented with the idea in view of incorporating the material therein into lessons which will ultimately be combined into a correspondence course. It is the further suggestion of your Papers Committee that a committee be appointed to consider this question and report to the convention before its adjournment.

Should such an educational program be decided upon, we would suggest that a standing committee be appointed which would be composed of representatives of each line of activity represented in this body. Each representative of the line of activity would become the chairman of a sub-committee covering that particular activity. The members of each sub-committee should be all the members of the Society interested in that particular subject. For instance, on the subject of the projection machine; one of the representatives of one of the manufacturers of a projection machine would become a member of the standing committee and automatically become chairman of the sub-committee on projection machines.

His sub-committee would be composed of all representatives of all manufacturers of projection machines who are members of the Society. It would then become the duty of each sub-committee prepare for presentation the lessons on subjects assigned to them. When such lessons have been completed they are presented to the standing committee for approval. Then the approval of the standing committee would carry it to the convention for final approval before publication.

We would suggest that the standing committee issue a prospectus of this course to determine the approximate return which would be forthcoming from projectionists or others desiring to enter such a course.

If sufficient students can be obtained, it is very possible that the Society might then maintain a general office and general secretary whose duty it should be to handle general Society business and also to handle the correspondence course.

We would suggest that the course be divided into about fourteen or fifteen lessons, somewhat as follows:

The first general subject would be the fundamentals. This subject would cover the fundamentals of electricity, of optics and illumination. These lessons would be very easy to prepare, inasmuch as there are already in existence many good courses of this nature which could be obtained with little trouble. The second general heading would be the Projection Room. This subject would be divided into such parts as the electrical considerations covering wiring, motors, motor-generators, transformers, mercury arc rectifiers, etc. Then, mechanical considerations which would cover such things as projection machines, rewinds, etc., then ventilation, its design and care, and the design and illumination of the projection room. Then we would suggest the study of applied optics, the study of the carbon arcs and the incandescent lamp. The next general subject would be the theater, its general design, location, consideration of safety and its ventilation. The next general subject might be the study of the screen, surfaces, location, cost, and a study of the causes of flicker and other peculiar effects that can be eliminated by the proper illumination and selection of screen surface. The final lesson might be on film, its care, distribution and cost.

If such a correspondence course could be prepared and properly brought before the projectionists' organizations, we feel sure that we could obtain their co-operation to such an extent that perhaps a certificate showing satisfactory completion of this course would be substituted for part of the requirements for a licensed projectionist. Such a course, if properly presented to city and state authorities, would greatly assist in standardization of projectionists' examinations and might even tend to stabilize local restrictions regarding motion-picture projection.

Respectfully submitted,

L. C. PORTER, *Chairman*

R. P. BURROWS E. L. BRAGDON MAX MAYER

Motion Pictures in Connection with Isolated Lighting Plants

By R. L. Lee

One of the most successful engineers I have had the pleasure of meeting once said that in building a piece of apparatus, he did not try to design it, but asked what it wanted to be and then made it accordingly. Evidently this was the plan under which the lamp engineers worked when they built the powerful incandescent projection lamps which are now being used so successfully. This must be the case, as if there was any way under the sun which to make a successful lamp for the universally used 110-volt service, they surely would have done it, and not built them for 30 volts.

In studying the isolated lighting-plant situation, a plan similar to this must have been followed, as the majority of the plants now being installed are 32 volts instead of 110 volts, which would have been very much more convenient from the standpoint of accessories. I do not believe that it would be interesting to you, or necessary, to go into the reasons why the average farm lighting plant is 32 volts instead of 110 volts. The fact remains that the voltage of both the incandescent motion-picture lamp and the individual lighting plant are the same, as it was due to this coincidence that I became interested in incandescent projection, and as a result of this interest, will attempt to tell you a little about the problems encountered and the situation as we have sized it up.

At the present time there are a large number of outfits equipped with independent lighting plants using incandescent projection. This may be divided into the following classes:

First: Portable motion-picture outfits for travelling exhibitors who exhibit in localities where commercial current cannot be secured, such as agricultural extension work, educational lecturers, specialty salesmen, etc.

Second: Small portable projectors for schools, churches, lodge halls, etc., in localities where commercial current cannot be secured.

Third: Small theatres having just a few exhibitions a week, in isolated districts probably using a local hall which at other times is used for other purposes.

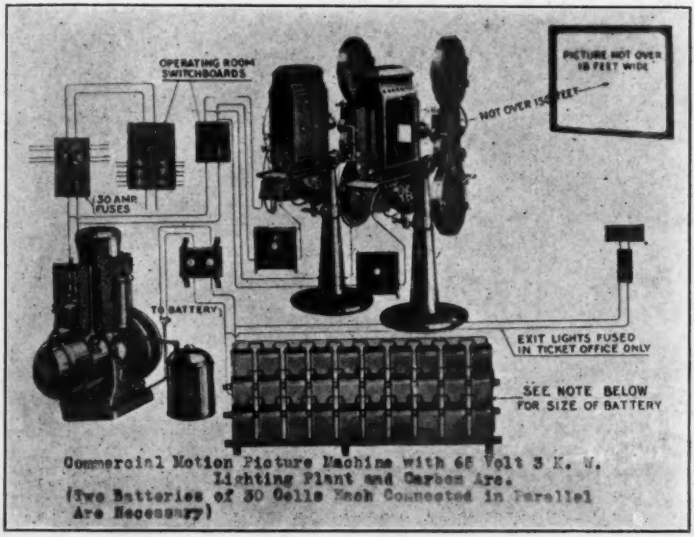
Fourth: Country theatres or small town theatres where other current cannot be secured or is so unreliable that good service cannot be extended to the patrons.

Fifth: Larger theatres where current costs are exorbitant; and

Sixth: Large town theatres wishing to protect their service from accidental shut-downs.

The speaker has been in personal contact with these various types of installations and believes that an enormous amount of work will be done in this direction in the future. It has been a rather bumpy road we have had to travel when you consider that at the beginning of this work it was very difficult to secure proper lamp houses for standard projectors, very little was known relative to the limitations of the lamps or the proper method of using them, and the care which must be taken with them, the difficulty of get-

ting projectionists to handle them properly; in fact, this work has been very discouraging at times. I believe that I will be safe in saying that the most of our difficulty was due directly to exaggerated estimates of the ability of the 600-watt 30-volt monoplane filament lamp. I am speaking of this as a result of our experience soon after its introduction. The data we had to go on was that compiled as a result of laboratory tests and which was perfectly correct, providing all conditions were ideal, that the adjustments were made accurately, proper screens used and everything in good working order. However, it was an entirely different problem after an outfit was placed in the hands of the man who knew very little about projection to start with, even though he was quite successful with carbon arc machines, who did not appreciate the necessity for careful adjustments, and where the theatres were not dark enough, where poor screens were used, etc.

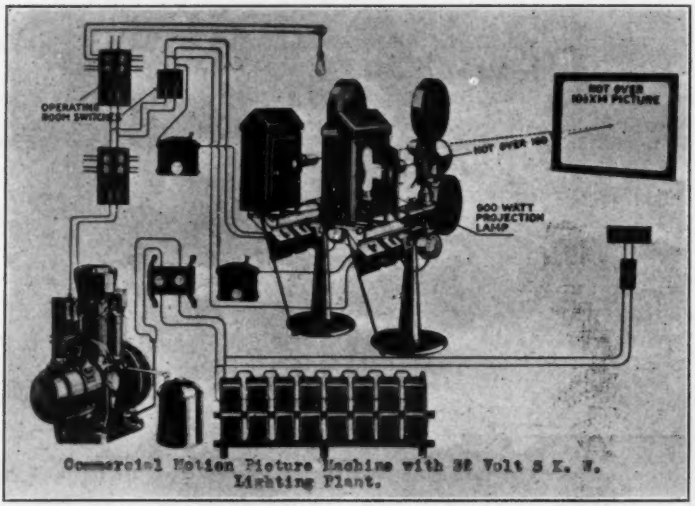

OPERATING ROOM SWITCHBOARD
PICTURE NOT OVER 10 FEET WIDE
NOT OVER 150 FEET
30 AMP. FUSES
TO BATTERY
EXIT LIGHTS FUSED IN TICKET OFFICE ONLY
SEE NOTE BELOW FOR SIZE OF BATTERY
Commercial Motion Picture Machine with 65 Volt 3 K. W. Lighting Plant and Carbon Arc.
(Two Batteries of 30 Cells Each Connected in Parallel Are Necessary)

After these experiences, therefore, we conducted tests in our own laboratory and then arrived at a definite sized picture and throw for the 600-watt lamp. We instructed our salesmen never to recommend a 600-watt lamp for a picture larger than 9 x 12 and a throw of 80 feet. This was, of course, conservative, as the speaker has seen various installations showing a larger picture at a greater throw very successfully, but as a result of our experience, and considering many conditions which could detract from the success of the installation, we thought it best to specify these limits and the success resulting from this practice more than repaid us for the

few installations which were not made due to not having large enough picture.

During the last four years, I have had an excellent opportunity of looking over many pieces of apparatus, and also of observing their operation in the field, and it appears to me that most of the difficulty in the various apparatus is not due to mechanical imperfection but due to the designer not considering the place in which it is to be used and the man or woman who is going to use it. One of the easiest things, and from my observation, the most unsuccessful, is taking some combination of mechanics or electricity, and attempting to force it onto the people, or in other words, to attempt to educate the public to conform to this piece of apparatus.

One of the most difficult and most successful methods of building a new piece of apparatus is to carefully consider the place in which the apparatus is going to be used and more especially



Commercial Motion Picture Machine with 32 Volt 5 K. W. Lighting Plant.

the man or woman who is going to use it, making allowances at all times for those things which the average person will not do, even though he has an instruction book as thick as the Bible.

It appears to me that the degree of perfection of any piece of apparatus is in inverse ratio to the thickness of the instruction book. I therefore believe that in the development of incandescent projection, one of the goals to work for is simplicity of construction and operation, as one of the main talking points of this method of projection is supposed to be simplicity, and the elimination of many of the duties which must be performed when using the carbon arc.

When I first went into this work about the only lighting plant made in any quantities had a capacity of 750 watts. This, of course,

limited our activities to very small theatres, the lamps taking 600 watts and with the generator running a surplus of only 150 watts, or slightly less, was left over for supplying the battery. If the battery was fully charged we figured that it would be possible with this combination to operate a theatre whose exhibitions lasted only five hours a day or less. You can readily see that this combination would be successful only in the smaller of "part time" theatres. We were therefore called upon for an outfit which would handle a larger theatre. About this time, 3-KW, 32-volt generator outfits appeared on the market and it was possible with them and the 600-watt lamp to handle larger theatres, operating an indefinite number of hours a day. Quite a number of these installations were made and from all reports are very satisfactory.

Due to the fact, however, that a limit of 9 x 12 was placed upon a possible picture at an 80-foot throw which would be entirely satisfactory, many requests appeared for outfits which would supply projection for larger audiences and theatres. It therefore became necessary to look around for something which would give us more light. We finally decided upon a 65-volt 3-KW generator with satisfactory battery and with it we could furnish screen illumination, etc., for practically any theatre excepting the larger ones. A number of these installations were made. We found after some practical experience that the light load, motors, etc., of the average theatre would consume enough current from the total output of the plant to leave only sufficient current for a 30-ampere arc. These installations were very satisfactory.

Later quite a lengthy discussion between the various lamp engineers was settled and a standard of 30-amperes, 30 volts, or 900-watt incandescent lamp was decided upon. We found that this lamp when properly installed and focused, would give us illumination equal to the 30-ampere direct-current arc. We therefore began to lose interest in the arc due to inconvenience in adjusting, etc., and concentrated in force on the 30-ampere incandescent lamp. This brings us up to the present time. At present, some difficulties are being experienced with the 30-ampere, 900-watt lamp, and it is my opinion that we had better go slowly until the lamp engineers give us their O. K. upon it.

I have given a brief history of my personal activities in this business and as a result of this experience, there are several principles which have been fortunately brought to my attention and which it seems to me are very important to the success of any engineering activity. As the only way through which the fruits of engineering may finally pass to a greater utility is through the sales force, it appears to me that the junction between engineering and sales activity is one of the most important points in any business. The salesman studies human nature and methods of overcoming prejudices and of painting pictures in the minds of his prospects and of creating a desire for the thing which he is selling. I have heard it said that if five per cent of what we tell someone else is actually digested, we are working very efficiently. In put-

ting in the 95% from my experience, I would say that there is a great temptation for the average salesman in his enthusiasm to stretch certain facts a certain amount and unintentionally make claims for apparatus which cannot be substantiated.

On the other hand, I would say that it is very easy for an engineer, when he is attempting to solve a certain problem, to get certain predetermined results, to coax the figures around a little bit toward the right direction and by accurately setting his apparatus, eliminate every feature which may detract from the maximum results and not considering that the fellow who uses this apparatus will know comparatively nothing about it, and will finally arrive at a figure entirely too high in relation to the actual performance of the apparatus.

When he turns these figures over to the salesman, who adds a little more on for good measure, the customer will be disappointed in the results he secures and it seems to me that there is nothing more discouraging to the salesman, manufacturer, and everyone connected with the project than to have a number of dissatisfied users. In fact, all the sales activity in the world attempting to combat this feature would result in failure.

I therefore believe that it is to everyone's advantage, even though we are all keyed up with enthusiasm and have accomplished wonderful things, to deal rather conservatively rather than to overestimate the results of our activities.

The salesmen, with whom I come in contact, are interested in many types and kinds of apparatus. It is therefore impossible for them to become experts in any one particular line. However, so that they may be able to understand the fundamentals of projection, I supervised the writing of a booklet made up almost entirely of diagrams and illustrations showing just what may be expected from isolated lighting plants in connection with projection. I have made a number of these illustrations into slides and will now show you an attempt to educate in a very simple manner, these salesmen.

Educational Possibilities of Motion Pictures

By B. E. Norrish

Education by the motion picture is daily being recognized as the education that counts and counts greatly. We all of us have the sense that is known as "eye-mindedness," more particularly the young. The moving picture is the simplest and easiest way known of imparting knowledge and information in an interesting and entertaining form. By means of the motion picture, every boy and girl, every man and woman, can take a post-graduate course in the greatest university of all—the University of the World.

Before the motion-picture screen, the languages of Babel tumble, for the new and great agent, the motion-picture screen, discloses a universal language and, no matter what the mother tongue of the gazer is, he understands and knows at once that which is displayed on the screen. This is the reason why the trade organizations and governments have intensively concentrated on motion-picture work during the past few years. By means of "eye-mindedness," thought impressions are being given through the motion picture to millions of every-day people. Get a people thinking along a certain line and what happens? You know as well as I do this is the way that epochal changes are brought about. By means of films, you can create and give thought impressions which will make people think Victory Bonds, More Production and all other things that are the necessity of the times in which we live. This is education and education with an end in view—the good and welfare of our people, our country, our schools, etc.

There is an old theory in psychology that a thought impression once gained never dies. It remains dormant and inactive in the brain, but will spring to life and action once there is created a sensation, or, rather, I should say, a sense perception like it again. Day after day, year in, year out, this process can be worked out in a system of distribution of films, and, as a consequence, each film or release acts as the sensation or sense perception that, by association with previous sensations, recalls to the mind, say, Liberty Loan, and with each succeeding release enlarges on and makes greater, finer and more appealing the thought of Liberty or Victory Loans.

All films can be pleasing to the eye. Education that is pleasant makes a pleasant and lasting appeal and this is the education that can be given to the people of the earth.

For instance, take scenic films. They show sport life of the mountain parklands—glorious sporting lakes and streams—holiday-ers having the time of their lives. Next summer holiday time, association of ideas will finally lead prospective tourists to think mountains, fishing, boating, etc., and then parks, mountains, trout, where found, come to their minds naturally as a result of the natural functions of the mind.

Ideas may be conveyed to the brain through the eye, the ear, or by means of feeling or smelling. The shortest path to the brain is through the eye, and the greatest part of every person's education

is obtained through the eye. By books the past generations have been educated. Thousands of paragraphs, miles of letters and mountains of syllables are gone over and mastered in the book studies of today. The eye is the medium whereby the monumental task of obtaining this kind of knowledge is made possible.

Take, for instance, Van Dyke's book on the mountains. Thousands of paragraphs are used to educate the novice as to what the mountain is and still the learner has not obtained a proper idea of a mountain. The motion picture at a glance brings home to the gazer or student a proper and concise conception of a mountain in all its interesting details where Van Dyke, master word painter though he is, used thousands of paragraphs to produce the same idea.

Consider what this means in child education and then realize why the motion picture is gradually but surely entering into the educational field as a valuable aid in education. Why should the teacher, for instance, have to take hours in teaching a boy about his country and then, as is shown by the quarterly examination, find out that much of his or her efforts have been useless? There is a reason clear and simple for this failure. The scholar has had to take into his or her mind by the ear the impressions which the teacher has been trying to give and also he has had to laboriously pore over the printed page cramming in his lesson.

It is a remarkable fact that seven-eighths of all knowledge is only acquired and understood after there has been flashed before the mind mental pictures by the millions. Every conception is only arrived at and understood after the mind has seen in mental pictures all the things that go to make up the conception or thought. For instance, a child does not master quantity or number until he has pictured in his mind a series of pictures. Let us take 4, for example. Until he has mentally seen that 2 and 2, or 3 and 1 make four, he does not really know what 4 is.

Seven-eighths of all acquired knowledge is thus obtained, the remaining one-eighth is simply mastered by memory or cramming without mental pictures being seen. This is weak and faulty knowledge. Picture-making thus forms the basis upon which real knowledge is acquired. Hard work it is too. The motion picture steps in now and, by natural law, performs a function which at once enables the mind without effort to take hold of and hold fast on its inner or mental picture, thus removing the laborious and tiring processes which the mind has had to undergo to get solid and well-balanced conceptions, or knowledge in the past. Motion pictures, therefore, naturally fit into all educational work and, as time passes on, the greatest function that will be performed by motion pictures will be that of teacher and mentor.

Let us just consider for a moment the course in geography. I know in my time I had to get my thought impressions of natural geography by cramming definitions. For instance—a mountain was described as a very high hill. There was a hill at home and I can remember today how my imagination piled up solid earth on

top of that very hill to get my impression of a mountain. What a farce the whole thing really appeared to me in after years when I actually saw and climbed a real mountain! By means of the motion picture at a glance a boy may get a correct and positive idea of a mountain.

What an awful job it was to master the industries of the countries of the world in the old days. Hours and hours of work, and then not half ready, I went with fear and trembling to the examination. What a Godsend would the good industrial pictures now produced have been at that time!

To illustrate, with the motion pictures we can now go to Vancouver Island, cut down a giant of the forest, transport it down the skidway to the Pacific, where it is made up with many others into a Davis raft. We can see it towed to the mill and there cut up into lumber, and then taken by scow to the railhead whence it lands in Toronto where the lumber is used to build aeroplanes. All the processes of manufacture are followed, and finally, the finished product takes its flight in the air, a beautiful aeroplane. Thus the student can actually see the workers of this industry at work and, in so doing, actually see the province or territory whence the natural product came. A teacher could talk for hours on this subject and still the student would only have but a hazy idea of the subject because he has only been taking in the knowledge through the ear, whereas by the film story—and there are many wonderful industrial films available today—he actually has had a living experience, for he has himself actually travelled to Vancouver Island, seen the lumber men at work and journeyed on until the product, a British Columbia spruce, is used in the manufacture of an aeroplane in Toronto.

And so it is with hundreds of other subjects. The student can go by the film story to the salmon fields, to the shipyards, to the grain fields, the elevators, fishing belts, the fruit valleys of the world, the mountain parklands, the summer resorts and playgrounds, water power areas, where he sees the processes by which hydro-electrical energy is obtained and applied, the irrigation areas where he sees for himself the how and where and why of irrigation. Millions of words, thousands of hours of hard plugging would only have given him a superficial knowledge of these subjects if he had never had the opportunity of living experience which only can be had by visiting the spots in question in body or by being carried thither by the picture story on the screen.

Give a boy or girl this opportunity, give him an examination, and compare the results with the answers that will be given by boys and girls who have only had the conceptions that are obtained by the book or spoken word and the results will be astounding.

The motion picture attracts the boy or girl student. It holds his interest. He journeys to the subject he is to study. He sees it. He sees what it looks like, what it does, what it is used for, and Excelsior! He is a boy with knowledge and information because he is really an explorer and traveller. This is why I base my claim upon the fact that as an educator the motion picture has come

to stay or plan an ever-increasing and more important part in the education of the race.

By means of the films, patriotism can be developed, love of country intensified, proper conceptions with regard to each portion of the country obtained and, best of all, a proper understanding of the relations of each individual part of the country to the whole and of nation to nation.

No college today has a complete equipment unless it has *a* picture machine and educational films. This is being recognized in Canada from coast to Coast.

Society of Motion-Picture Engineers
Report of Committee on Progress

By A. R. Dennington

A review of the motion-picture industry during the past six months or year shows a number of improvements which have been made and which help to bring the motion-picture industry into greater prominence than before. The object in writing up this review is to summarize briefly some of the notable steps which have been taken by the manufacturers of equipment and the producers of film. It is not within the province of this paper to go into detail regarding any of the matters taken up, as these subjects will in most cases be covered by other papers prepared by those who are more familiar with the details than are the various members of the Committee on Progress. It is hoped that the report may be of value in merely pointing out the general lines of improvements. It is to be feared that some fields may not have received the attention which they merit because of the impossibility of securing from those interested in different lines all of the information which would have proven helpful. However, the Committee wishes to thank the various contributors who have supplied the information which has been used as a basis for this paper.

Standard Motion Picture Machines

Among the developments which have appeared on standard motion-picture machines, and which help to make these machines more easily operated and more effective, are the following:

An arc lamp with the carbon placed at 90° to each other, and having a magnetic field to control the arc, has been developed, tested out, and found to be very efficient. The increase in efficiency is due to the fact that the crater of the positive carbon can be made to squarely face the condenser. The magnetic field used keeps the arc centered on the positive carbon so that the crater does not wander around, and the carbon burns off uniformly. The small negative carbon used can be brought entirely outside of the angle which includes the condenser, so that there is no shadowing of any part of the screen. It is estimated that a 35-ampere arc on the 90° arc lamp is fully equivalent of a 50-ampere arc on the older type of mechanism.

The difficulty which is experienced by some operators in maintaining an arc at the proper focus of the optical system and keeping it steady so as to produce a clear screen, will be entirely overcome by the use of arc controllers which are now being manufactured and placed on the market. The arc controller has been used for some time past in a few instances, but has never been developed to such an extent that it has become a usual part of the equipment. New designs of arc controllers are such that the mechanism has been considerably simplified, and the action is therefore more reliable and the equipment can be sold at a lower price, thus making it available in many theatres where in the past it would not have been considered. The proper focusing of the arc is such an impor-

tant feature of good projection that the new arc controllers will undoubtedly prove of special value in making possible a higher standard of projection.

The development of motion-picture theatres costing millions of dollars has emphasized the fact that in the past no projection equipment was available which adequately matched the completeness of equipment used in all parts of the house excepting the projection room. In order to overcome this lack of co-ordinate equipment there has been a tendency to develop complete projection units or complete units which will, when properly installed in the projection room, enable the operator to give better service than has been possible in the past. These units are something in line with the complete units suggested by Mr. Jenkins in a paper before this Society some two years ago. The complete projection unit equipment includes extra projectors, which can be used in emergency if there is an accident to any one of the machines. The generating equipment is now installed in duplicate, which is a practice to be recommended as it enables the operator to clean and oil one of the machines and have it ready for service while the other is running. Where only one machine is used there is little time for adjustment and repair, with the result that the machine deteriorates more rapidly than if it had proper care, and there is also risk that it may not be in operating condition when required for the regular performance. The installation of duplicate equipment is a step in the right direction, and it marks a development which has come into much greater prominence in the last year than heretofore.

As an aid to the projectionist in determining whether or not the arc is operating properly a reflector and lens has been arranged so that the image of the arc may be thrown on the walls, ceiling or floor of the projecting room. This enables the operator to tell at a glance the general condition of the arc without glancing through the peep hole in the lamp housing. The image of the arc is not so bright as to cause discomfort to the operator and he is therefore able to keep his eyes in better condition for properly focusing the picture on the screen and giving the patrons best results.

In order to determine the time when change-over should be made from one machine to another, a counter has been developed which shows the number of feet which have been run off the reel. This equipment is extremely simple in construction and reliable in operation. It is necessary only for the operator to set the dial at zero when a new reel is installed. As each foot of film is run off, the counting device, which is of the cyclometer type, advances one numeral. There are other modifications of this same device, and it is of service to the operator in adjusting the speed to run his film in the specified time, and also for determining the length of reel. The present tendency of splicing two 1,000-foot reels together in order to reduce the number of change-overs from one machine to another has brought out the importance of having as nearly as possible uniform tension on the film. With a 2,000-foot film the tension at the start with the usual equipment is very much greater

than is necessary, and this results in undue wear of the film. If the tension at the beginning is made small there will not be sufficient tension to insure that the filament will be taken up when the reel is nearly full. The difference in tension has been overcome in the new type of reel which has been developed. The new reel has a loose wooden hub on which the outer metal part slides. The hub is turned and when the reel is empty there is sufficient friction between the hub and the metal rim to take up the film without undue strain. As the film builds up on the lower reel the weight increases and the friction also increases, thus giving a practically uniform tension, depending upon the weight of the film on the spool for the pull which is required.

Another refinement which has been noted in standard motion-picture machines is the use of a small incandescent lamp placed inside the lamp housing. This lamp can be lighted when it is necessary to change carbons or make other adjustments on the mechanism. This insures that the operator will have ample illumination inside the lamphousing without the necessity of using a portable light, which is more or less troublesome to handle and at best can be considered only a makeshift.

Arc Lamp Carbons

Carbons for the arc lamps used in picture projection were prior to the war imported at the rate of approximately twelve million per year. These carbons were manufactured under labor conditions which made it impossible for American manufacturers to compete, and the industry was developed only through the experimental stage. However, when the war broke out in 1914 the importation of carbons soon ceased and the American manufacturers were called upon to supply the carbons for the entire trade in this country. This meant the construction of large plants, the development and installation of special machinery, and the perfection of manufacturing processes. The result has been very gratifying, as the American made product of today is far superior to the imported carbons of a few years ago. The superior results which are obtained are due to a number of points which merit attention.

The upper carbon for the direct current arc is now composed of a hard specially constructed electrically conducting material, surrounded by a heat-insulating compound embedded within a star-shaped core. The core enables the arc to be centered almost the instant the current is applied, and the old system of burning the carbons for five or ten minutes in order to get a proper crater has been entirely discontinued because unnecessary. The carbons are also made up so as to have a maximum current carrying capacity, so as to increase the illumination per unit of crater area, and enable a firm arc to be maintained with very few adjustments.

The negative carbons on direct current arcs are now usually small in size and are plated with metal so as to increase the conductivity. The negative carbon acts merely as a conductor to carry away the current, and it has been found that the smaller this con-

ductor can be made, the better, and the less is the interference of the light from the positive crater.

Special carbons have been developed which are usually sold in sets, consisting of one 12-inch upper carbon and two 6-inch lower carbons. It is extremely essential that the carbons should be used in the manner designated, as the composition of the carbons is such as to give best results only when the upper carbon is used in the upper holder and the tip presented to the condenser. In the manufacture of this combination a special chemical water glass is used in the upper carbon and a small amount of rare earth in the lower carbon. The yellow tinge in the beam which has heretofore been characteristic of many of the alternating-current arcs, has thus been eliminated, and the picture is projected with a clear bright white light.

There is a very marked tendency toward the use of high current arcs. Where the standard a few years ago was for 35-50 ampere arcs, the present demand is for arcs rating at from 75 to over 100 amperes. There is a possibility that with the growing use of the 90° arc these higher current values may be somewhat reduced.

Gas-Filled Incandescent Lamps for Projection

The growth in the use of incandescent lamps for projection purposes has not been rapid because of the necessity of further development work on various points in the lamp and equipment. One of the most notable changes has been in the lamp itself and has to do with the interior construction.

Experiments have shown that with the filament supported in an upright position, and anchored firmly in place, there is a tendency for the coils to warp because of the expansion and contraction as they are heated and cooled. In order to overcome these difficulties the coil has been suspended from the leading-in wires and expansion joints placed in the lower supports so that the filament is free to expand and contract, but is held in correct position and alignment by the supports.

The lamps for the smaller or portable motion-picture machines have remained with very little change, though there is a tendency to use filament of monoplane construction wherever possible, as the effects produced on the screen are better than with the more usual types of filament arrangement. There are also proposed some changes in bulbs to meet the requirements of the small motion-picture machine. Most of these machines require bulbs with fairly small overall dimensions, and in many cases tubular bulbs are essential.

Electrical Equipment

The electrical equipment used in motion-picture projection has been so well standardized in the past that the last six months or one year has shown very little change. There have been developed and placed on the market a number of constant current regulators for use with incandescent projector type lamps, and controlled

regulators have also been perfected so as to give closer regulation and more accurate adjustment of the current. No changes have been reported on the usual type of projection room equipment, such as motor-generator sets, regulators, etc.

Optical Systems

The optical systems have remained unchanged where arc lamps are used. The increasing length of throw in the larger theatres results in a demand for larger objectives. The mountings of lenses are standardized and the manufacturers of lenses are preparing to meet the demand for larger objectives.

For incandescent lamp projection there are two systems of condensers which are commonly used at this time. These two systems are the plano convex condenser system and the prismatic condenser system. Both systems seem to be well established and doubtless will continue to be used. In the smaller portable machines there has been a tendency to use prismatic condensers of small type and short focal length.

Studio Lighting

In the methods of studio lighting there has been reported no change in the period since our last meeting. The systems used are the arc lamp, mercury vapor lamp, and in some cases the incandescent lamp. Improvements in the arc method of illumination of studios are in the carbons and in the use of large currents to get more powerful units. Mercury vapor lamps have been improved so as to be moved and directed more easily. Incandescent lamps and lighting systems for studios have not been appreciably modified and are commonly used in conjunction with other systems of illumination to secure special effects.

Tests of Screen Illumination from Motion-Picture Projectors

By W. F. Little

Field illumination for motion-picture projection may be studied by several different methods. Here the experience of the Electrical Testing Laboratories may be of some service and it is the purpose of this paper to present some notes on such tests.

In order to make comparisons between the different methods of study a constant light source or the incandescent lamp was used.

Intensity

As the light intensity in the field is more or less a function of the field area, the problem in this connection is to determine the flux in lumens through the objective lens.

Uniformity of Field

The field brightness may vary considerably without greatly affecting the appearance of the picture for the reason that the variations in intensity are gradual.

Test Methods

As all the light passing through the objective lens reaches the screen, the quantity of light may be investigated either on the screen or at the objective. Photometric measurements may be used to determine the field intensities by making measurements at the screen. The usual practice is to divide the entire field into equal areas and make measurements in the center of each. The nearer the observation area conforms to the area to be investigated the more accurate is the integration secured. Therefore, in order to cover the entire field these areas should be either large, or numerous. If the observed portions comprehend too large an area, the light intensity variation may be lost sight of. If the measurements are made at the objective, the results will bear no relation whatever to the uniformity of the field. Therefore, the testing may resolve itself into two distinct methods; first, that of the measurements of light upon the screen, and second, that of the measurements of light at the objective. The first may be again subdivided (a) including relatively few measurements, each measurement integrating over a comparatively large area, and (b) a large number of measurements, the average of which produces a close approximation of total flux and a fair index of uniformity; this latter method gives the most complete data.

The optical bar with which the experiments were made consisted of objective, aperture plate, condenser, lamp and spherical mirror, all located as in a motion-picture projector. An illustration of this equipment appears in the Transactions of this Society, No. 6, Fig. 16, page 68.

The photometer employed in tests of field illumination is so designed that the inequalities in field brightness throughout the observed area are obliterated, the surface appears uniform, and the brightness equal to the average brightness throughout the surface.

The other test apparatus used in the investigation was as follows:

Throw	60 feet
Objective lens	E.F. 5.5, D.2.5, *F.2.2*
Aperture	$\frac{11}{32}$ x $\frac{33}{32}$ inches
Condenser lens	2½ x 6½
Lamp	Mazda — 900 watt, 30 amperes
Spherical mirror	2¾ inches O.R.C.
Field area:	10 feet x 7 feet, 9 inches

With an incandescent light source, slight variations in symmetry of filament or filament alignment may produce a variation in light intensity upon the screen. Therefore, it is advisable to explore the entire field. An accurate alignment of the apparatus is highly essential, therefore the entire test procedure may be simplified if the test-plate and photometric equipment are fixed and the projector is adjustable.

When using a fixed test-plate and photometric equipment, the projector may be accurately aimed by the aid of a telescope and cross-hair. The telescope should be mounted over the pivot about which the projector turns and focussed upon a chart plotted on cross-section paper. A diagram of the field may be readily plotted to scale upon this cross-section paper and mounted in any convenient direction at such a distance from the telescope that the angle subtended by the chart is exactly equal to that subtended by the field. The centering of the cross-hairs upon the center of each test area as shown on the chart will bring the corresponding field areas to the proper position on the test-plate.

If the light source be an arc, the distribution of light intensity over the screen should be fairly symmetrical for the reason that the major portion of the light emanates from the small round crater. However, because of the light fluctuations when studying projection with an arc lamp, it is advisable to use two photometric equipments, one for observing the center of the field, the other for exploring purposes making the measurements simultaneously. In this case it is essential to keep the projector and one photometer fixed. The readings taken with the exploring photometer may then be corrected to the fluctuations of the arc as secured by the fixed photometer.

For the purpose of study, photometric measurements were made on the screen surface, dividing the field first into 16 and then into 256 equal rectangles.

16-Point Method

When dividing the field into 16 equal rectangles, fairly adequate integration should be secured if the observed test surface represents at least 40 per cent of the area of each rectangle.

The ellipse in the upper left rectangle on plate 1 shows the relative size of the observed area as compared with the rectangle.

256-Point Method

In dividing the field into 256 rectangles rather than 16, the observed area may be relatively smaller with respect to the rectangle and still render good results. As the light intensity falls off toward

10.0	11.1	10.9	9.4
10.5	11.6	11.0	9.8
10.0	11.6	11.0	9.4
8.6	10.1	9.1	7.5

Fig. 1.—Measurements Made by 16-point Method.

10.0	10.7	11.0	10.7	10.9	11.1	11.4	11.5	11.3	10.8	10.6	10.1	9.9	9.4	8.7	6.9
10.7	10.8	10.7	11.0	11.1	11.1	11.7	11.8	11.6	11.2	10.8	10.2	9.9	9.7	8.9	7.7
10.3	10.8	10.9	11.1	11.2	11.5	11.7	11.6	11.8	11.2	10.9	10.7	10.6	10.2	8.9	7.4
10.3	11.2	11.4	11.5	11.6	11.9	12.4	12.4	12.1	11.5	10.8	10.7	10.7	10.5	9.4	7.2
10.9	11.2	11.3	11.2	11.4	11.6	12.3	11.9	12.0	11.5	11.1	10.9	10.7	10.2	9.4	7.6
10.3	11.2	11.1	11.4	11.5	11.6	12.0	12.0	11.9	11.5	10.9	10.6	10.4	10.2	9.5	7.8
10.6	11.6	11.7	11.5	11.4	11.4	11.6	12.0	11.7	11.1	10.9	10.6	10.6	10.3	9.4	7.9
10.8	11.1	11.4	11.1	11.5	11.6	11.7	11.9	11.7	11.4	11.1	10.8	10.7	10.3	9.4	7.9
9.7	11.2	11.2	11.3	11.4	11.6	11.7	11.9	11.6	11.4	10.8	10.4	10.2	9.9	9.4	7.6
9.8	11.1	11.1	11.1	11.2	11.3	12.1	12.1	11.8	11.5	10.6	10.5	10.0	9.8	9.1	7.6
10.4	10.6	10.6	10.6	11.0	11.1	11.3	11.5	11.5	11.1	11.1	11.0	9.7	9.5	9.0	7.4
9.0	10.2	10.2	10.3	10.6	10.9	11.0	11.3	11.4	11.0	10.3	9.9	9.4	9.1	9.1	6.9
8.7	9.9	9.9	10.1	10.6	10.7	10.7	10.7	10.7	10.3	9.6	9.0	8.8	8.6	8.4	6.8
8.4	9.3	9.4	9.6	9.9	10.3	10.4	10.5	10.2	9.6	9.1	8.4	8.2	8.0	7.8	6.7
6.9	8.2	8.2	8.8	9.3	9.1	9.4	9.3	9.1	8.4	7.9	7.8	7.7	7.4	6.9	6.0
5.6	6.9	7.3	7.4	7.9	7.9	8.2	8.1	7.7	7.1	6.8	6.4	6.7	5.9	5.3	4.7

Fig. 2.—Measurements Made by 256-point Method.

the edge of the field, the 256-point method should show somewhat lower light flux than the 16-point method as the observed areas do not quite reach the screen edges. With a field of approximately 8 by 10 feet, the outer rows in the 256-point method are 2 inches or less from the edge of the field.

Measurements at the Objective

As previously stated, all the light passing through the objective falls within the field. Therefore a single photometric measurement of light flux at the objective may represent the flux upon the screen.

The measurement of light at the objective is not as simple as might at first be expected for the reason that the flux density is very high; through an aperture of approximately 1.5 square inches, a flux in the neighborhood of 800 to 1,500 lumens may pass. Assuming 800 lumens, the flux density would be 530 lumens per square inch or 76,500 lumens per square foot, which is equivalent to the illumination produced by a lamp of 76,500 candlepower at a distance of 1 foot.

In making these measurements, a photometer and a 3-inch velvet lined tube 24 inches long were used. At either end of the tube white diffusing plates were placed and a light filter which served to correct the color of the light to that of the comparison lamp in the photometer.

The two diffusing plates which were separated by 24 inches were employed for the purpose of reducing the light intensity to a value which could be conveniently measured.

The photometer was calibrated in connection with this tube in terms of the 16-point method, and this standardization was maintained by retaining several incandescent lamps as standards. These lamps are burned somewhat low in order to increase their life. It was found by experience that this method of maintaining the standardization was very reliable.

Table 3 shows a series of measurements where the same standard lamp was used, refocussing it four different times. Between set-ups the lamp was removed from the socket and the spherical mirror location changed. The maximum variation from the mean is plus or minus ¾ of one per cent. Another method of verification is to project the beam into an integrating sphere, thus determining the total flux.

Table 3. Reproducibility of Results of the One-Point Method Using a Standard Lamp

Per Cent Lumens on Screen	
Without mirror	With mirror
100	162
101	164
101	165
101	162

Analysis of Results

A comparison of the three sets of determinations, namely the 16-point, the 256-point and 1-point methods, shows them to be

in substantial agreement. However, in this particular test, the standardization of the photometric equipment used for the one point, measurement was made to agree with the result as found by the 16-point method; therefore they should and do agree. This is shown in Table 4 where a number of lamps were measured by both methods, the photometric equipment for the 1-point method being standardized with an incandescent lamp.

TABLE 4. COMPARISON OF 16-POINT AND 1-POINT METHODS

NO. OF LAMPS MEASURED	LUMENS ON SCREEN 1-POINT METHOD AVERAGE	16-POINT METHOD AVERAGE
10	838	835
6	728	726
6	589	594

The 256-point method is slightly low, though it should be expected that the results would be even lower by reason of the proximity of the outer rows to the edge of the field, the outer row being considerably lower than the average. The test results of both the 16-point and 256-point method (plates 1 and 2) show that the plane of the filament is not exactly normal to the projector axis, since the lowest intensity is found in the lower right quadrant, the highest intensity in the upper left quadrant. The average of each quadrant by the 16-point method and that of the 256-point method is shown in table 5.

TABLE 5. AVERAGE FLUX IN QUADRANT

	16-POINT METHOD	256-POINT METHOD
Upper Right	10.0	10.2
Upper Left	10.8	11.3
Lower Right	9.3	8.9
Lower Left	10.0	10.0

By a study of the 256-point method, it will be seen that the field uniformity bears little or no relation to the disposition of the filament coils or coil image. It might be expected that seven distinct vertical high ridges would be found to conform with the filament coils and coil images whereas the highest intensity is in the center of the field with a more or less gradual tapering off toward the edges with a greater taper toward the sides than toward the top and bottom. The superimposition of the filament image between the filament loops fill up and smooth out the field intensity.

An independent verification of the 1-point method was obtained by securing the transmission of the diffusing plates in the tube, the results of which showed the values for the 16-point method 4 per cent high. Again this would indicate that the 16-point method gives results which are slightly high.

INTENSITY INCREASE FROM MIRROR

The spherical mirror increases the screen illumination by filling up the gaps between filament loops and increasing the filament temperature by reflecting heat upon it. With a total increase of 70 per cent in screen illumination, 46 per cent may be attributed to the extension of the light source due to the image and 14 per cent to the temperature rise in the filament.

In table 6 will be found data showing the increased illumination with the use of the spherical mirror.

TABLE 6. PER CENT INCREASE DUE TO MIRROR

Average of 10 lamps selected at random	67%
Minimum	65%
Maximum	73%

The effectiveness of the mirror decreases with the life of the lamp; this is caused by the distortion and spread of the filament coils and the inability of the mirror to fill up the gaps.

INTENSITY CHANGE WITH CHANGES IN ELECTRICAL VALUES

During the test the current was supplied from storage batteries so that the necessity for correcting the variation in electrical values was eliminated. However, the attached characteristic curve, Plate 3, illustrates the variation in screen intensity resulting from variation in electrical values.

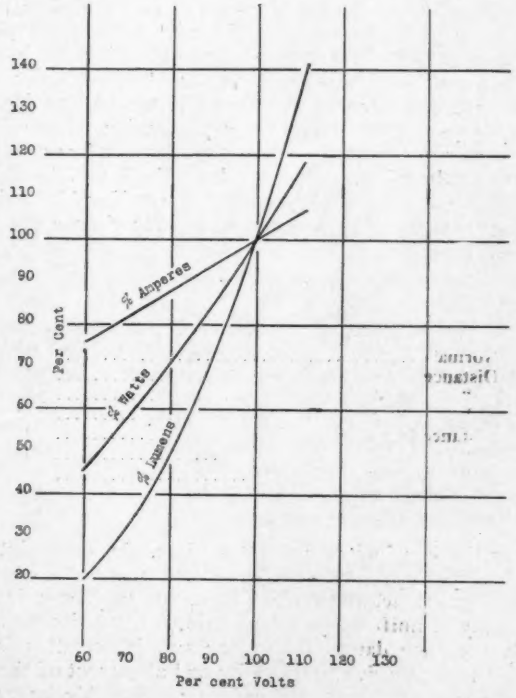


Fig. 3.—Characteristic Curve Showing Variations in Screen Intensity.

Screen Flux in Relation to the Lamp Temperature

In general other things being equal, the test results show that the screen intensity varies with the filament brightness. Many apparent conflicting results are found though these may be attributed to filament irregularities.

Focusing

Supplementing results shown in the paper on "Some Considerations of the Application of the Tungsten Filament Lamps to Motion-Picture Projectors" appearing in the transactions of this Society, some experiments were made on the focusing of the lamp and spherical mirror. Mr. Porter and Mr. States show diagrams which indicate the change in screen lumens due to spherical mirror and condenser being moved from the correct position.

Assuming the correct position for the condenser, aperture plate and objective lens, some experiments were made to determine the position for the lamp filament and spherical mirror in order to secure the highest field intensity. The method employed was to so place the lamp filament as to produce a filament image on a plate placed at different positions in front of the objective lens. This plate was moved from a position almost in contact with the outer lens of the objective to a position several inches in front of the objective, each time positioning the filament so that its image was projected with the best definition obtainable. In each position of the lamp the spherical mirror was placed so that the filament image was dovetailed between the filament loops. In table 7 will be found the results of this study. It indicates that a considerable variation in the position of this screen will not materially change the quantity of the projected light.

Table 7

POSITION OF PLATE	PER CENT LUMENS
Normal	100
Distance decreased ¼ inch	99
" " ¾ "	99
" " 1½ "	97
Distance increased ¼ inch	99
" " ¾ "	100
" " 1¼ "	99

Conclusions

Basing the conclusions upon test data, the one-point method produces satisfactory results for quick and accurate comparison of light sources where field uniformity has previously been determined. Where a study of uniformity is important, the 16-point method gives reasonably complete data. Where the full information is desired with respect to screen flux, uniformity and alignment of the filament and optical parts, a method employing a considerably larger number of test areas should be used.

The Tinting of Motion-Picture Film

By G. A. Blair

The problem of suitably coloring the motion picture is now occupying the attention of many serious workers in the industry. Some few years ago the plain black and white picture was in itself a sufficient novelty to interest the public and color was of no particular consequence, providing the story was sufficiently interesting. Times are changing, the public is growing more exacting in its requirements and the demand for color is evident from the fact that from 80% to 90% of the film now being produced is tinted.

In spite of the success attained by many workers in producing multi-color pictures by purely photographic means the expense involved reduces the prospect of the natural color picture coming into universal use for some time to come, so in the interval the majority of film will be colored by improved methods of tinting and toning.

Tinting

Tinting, as usually understood, consists in immersing the film in a solution of dye which colors the gelatine, causing the whole picture to have a uniform veil of color on the screen, though there are other ways of producing the same effect as follows:

1. By the use of color screens at some point in the path of the beam of light in the projector. The color screens may consist of sheets of colored glass or of dyed gelatine similar to the usual photographic filters, conveniently mounted in a circular rotating holder placed in front of the projector lens. This method is very satisfactory if a long run of film is to receive the same tint, though if the tint has to be changed between scenes some mechanically operated arrangement is necessary.

Interesting effects may be secured by using a compound filter composed of two or more sections placed at a suitable distance in front of the lens, so that one color will diffuse into the other on the screen.

2. By "flood lighting" the screen, which consists in throwing beams of colored light onto the screen from the wings. This method is fairly effective but necessitates the assistance of one or more operators.

3. By coloring the film base. Apart from the manufacturing difficulties involved in producing such film the limited number of prints which could be supplied would not warrant the demand for the infinite variety of shades and tints employed by various producers.

4. By coloring the gelatine by means of inorganic salts. This interesting method depends upon the fact that certain inorganic metallic salts, such as uranium and iron ferrocyanides, lead sulphide, etc., in the colloidal condition are highly colored. The method of tinting consists in precipitating the colored salts within the gelatine by first immersing the film in a weak solution of—say, uranium

nitrate, rinsing and then placing in a weak solution of potassium ferrocyanide and washing. The depth of tint depends on the concentration of the solutions and on the time of rinsing before immersing in the ferrocyanide. The color does not bleed but in view of the labor involved and the limited number of colors available the method is inferior to that of tinting with dyes. (See *Motion Picture News*, December, 1918, p. 3941.)

5. The method of tinting with dyes is the most satisfactory and is almost universally employed. The dye can be applied to the film by means of application rollers or by floating the film across the surface of the dye or by spraying, though the method of dipping, as in development, is in most general use.

Success in tinting depends on the correct choice of dyes and the correct methods of their application.

Choice of Dyes

Dyes are of two kinds, acid and basic, depending on their chemical composition, acid dyes being alkali salts of organic acids while basic dyes are the chlorides, sulphates, etc., of organic bases. The two classes of dyes may be distinguished as follows:

(a) When a solution of an acid dye is mixed with a solution of a basic dye, both are mutually precipitated and come out of the solution, and this property is made use of in testing whether a dye is acid or basic. It is simply necessary to add a solution of a known basic dye; for example, methyl violet to the unknown dye solution, and observe if the solution remains clear (indicating a basic dye) or becomes turbid (thus indicating an acid dye).

(b) Another method consists in immersing the edge of a piece of blotting or filter paper in the dye solution. In the case of a basic dye, as the color runs up the paper, a colorless band precedes the band of color as if the paper were filtering the water from the dye, while with an acid dye no such line of demarkation is noticed.

(c) Another interesting property of basic dyes is that an acid solution does not usually dye gelatine as rapidly as a neutral solution, while with most acid dyes the rate of dyeing is considerably increased by adding acid.

None of the above tests is absolutely conclusive, though in the absence of the more refined chemical tests if all three confirm each other they may be considered as conclusive.

In view of the opposite nature of acid and basic dyes, it is obvious that if several dyes are to be mixed one with another to produce intermediate tints they must all be of the same class. Since the number of acid dyes of suitable color is far in excess of the number of basic dyes, thus giving greater selection, and since acid dyes are usually more stable to light, they are the most suitable for tinting.

Properties of Acid Dyes

Dyes suitable for tinting should possess the following properties:

1. The dye should not "bleed" to any considerable extent when the film is washed; in other words, the rate of removal of the dye should be slow and only a slight amount should wash out in a period of—say five minutes.

In tinting, bleeding is of very considerable importance, since during the period between rinsing after dyeing and the placing of the film on the drying racks, any drops of water on the surface of the film become more or less saturated with dye, and these, after drying remain as spots and irregular markings which are very apparent on the screen.

It is possible in some cases to modify this bleeding by an acid "stop-bath," or by adding acid to the dye-bath, though it may be considered a general rule that the bleeding of a dye is a property particular to itself. In selecting dyes it is therefore necessary to choose only those whose propensity for bleeding is a minimum.

2. The dye should not be precipitated by alum, calcium (lime) magnesium, or iron salts. A large number of dyes are readily precipitated by these salts, the result being that if the water supply contains a slight amount of—say alum or calcium salts, or if the film is for any reason not thoroughly washed after leaving the alum hardening fixing bath, the dye precipitates in the tank as a sludge and produces a spotted effect on the film. Hard water, which may contain carbonates, bicarbonates or sulphates of calcium and magnesium, is therefore liable to give trouble with unsuitable dyes. The use of distilled water for mixing the dye solutions will partly eliminate the trouble, though a supply of distilled water is available in very few film laboratories.

In many localities the water supply is treated with compounds containing alum and iron salts to precipitate vegetable colloidal matter in suspension though after settling, the water still contains alum in solution, and also any previously dissolved salts, which cause the trouble.

The dyes recommended below are not readily precipitated by alum, calcium, magnesium, or iron salts and a large number of dyes while otherwise suitable for tinting film have been rejected because they failed to stand this test.

3. The dye should not be "dichroic" or change color (hue) on dilution, otherwise it is difficult to repeat results and match any given tint. The dye should also be fast to light even under the heat of the projector, otherwise local fading would result in patchiness on the screen.

4. The dye solution should not froth readily, otherwise foam accumulates on the surface of the tank, especially when the drum system of tinting is employed and clings to the film even after rinsing.

5. The dye should not be affected by the acid-fixing bath since

any fixing solution accidentally splashed thereon will destroy the dye immediately. Great importance has not been attached to this test since hypo should never reach the tinted film. It has been impossible to collect a complete set of dyes which will pass this test, though in choosing between two otherwise satisfactory dyes the one affected by hypo has been rejected.

6. The dye should be inert and not attack the gelatine coating of the film even after incubating for 24 hours at 212 degrees F. This is of fundamental importance otherwise the film becomes brittle and its wearing qualities are impaired.

BRITTLENESS OF FILM.

Complaint is sometimes made that film is lacking in physical properties, and in many cases this is apparently so, but due to no fault in manufacture. Projecting conditions have changed. Whereas 20 to 30 amperes was considered sufficient for projection, owing to longer throws necessary in the larger theatres, many houses are using considerably over 100 amperes. In the interval between successive showings the film has not time to cool, the result is a continual baking of the film which affects its flexibility and with other factors produces brittleness. These factors may be tabulated as follows:

1. The corrosive action of the dye itself. Several dyes when employed at a concentration of 1% attack gelatine readily at 70 degrees F. and vigorously at 80 degrees, especially in the presence of small amounts of acid, producing a marked softening and often partial dissolution of the film. The effect is roughly proportional to the concentration of the dye and to the temperature, and varies with each individual dye.

Experience has shown that the gelatine coating of film which has been softened in this way by the dye becomes brittle on subsequent projection. The effect is due partly to the particular chemical constitution of the dye itself and also to the impurities mixed with the dye. Commercial dyes are prepared by "salting out" the dye by adding common salt, sodium sulphate and other chemicals to the dye solution so that unless the dye is subsequently purified it contains sodium chloride or sodium sulphate with more or less iron which has a tendency to harden the film considerably.

2. The hydrolising action of acid which in many cases is added to assist in dyeing. The addition of acid to a solution of an acid dye usually has the effect of increasing the rate of dyeing while in the case of a basic dye the rate of dyeing is diminished. With acid dyes, acid also tends to fix the dye in the gelatine and therefore diminish the rate of bleeding. In such a case only a volatile acid, such as acetic acid, should be used, since this will mostly evaporate on drying. If a solid acid, such as citric or tartaric is used, this remains in the film on drying and under the influence of the heat of the projector, especially in damp weather, the acid soon begins to decompose the gelatine film.

The effect of acid on gelatine is readily seen by adding a few pieces of gelatine to a strong solution of acetic acid. The gelatine

soon disolves, forming a liquid glue which when dry is much more brittle than gelatine.

Acid in any form is therefore undesirable as far as the wearing qualities of film are concerned, but if it is used the concentration should not exceed 0.05% or 1 part of glacial acetic acid to two thousand (3 oz. per 50 gal.) otherwise softening of the gelatine is liable to occur especially if the temperature of the dye-bath exceeds 70 degrees F.

It is common practice in many film laboratories, when the dye bath works slowly to add a further quantity of acetic acid to increase the rate of dyeing. This is done repeatedly until the dye-bath contains practically no dye at all and a strong odor of acetic acid is present in the drying room. Such maltreatment of film is responsible for most of the complaints of brittleness and is to be deplored. The cost of the dye is insignificant as compared with the value of the film treated so that a dye-bath of sufficient strength should be made in the first place and a strong solution of the dye added as required in order to revive the bath. Fifty gallons of dye bath of a concentration of 0.2% will usually tint 40,000 feet of film.

Choice of Colors

Although it is possible to match any tint by suitable admixture of one or more of three colors, magenta, yellow and blue green, when mixing colors in this way the mixing must be done with great precision since a slight variation in the quantity of any one of the ingredients produces a marked effect, so that it is simpler to include intermediate colors, such as orange, green, etc., as standard tints.

Seven standard tints have been chosen: namely, red, scarlet, yellow, light green, green, blue and violet. The problem of matching tints with standards is then a simple matter.

In selecting any particular dye, account has been taken of the purity of its color. Some dyes have a muddy appearance as if a certain amount of black dye had been mixed with it. This has the effect of diminishing the screen brightness so that in order to maintain constant screen intensity more current must be used in the projector. The purity of color of the dyes selected below is sufficient for all practical purposes.

American Film Tinting Dyes

The following American made dyes which fulfill the above conditions as nearly as possible are recommended for film tinting:

TINT	NAME OF DYE	OBTAINED FROM
Cine Red	Amaranth	Calco Chemical Co., N. Y. C.
Cine Scarlet	Crocein Scarlet MOO.	Natl. Aniline & Chem. Co., N. Y. C.
Cine Yellow	Quinolin Yellow	Natl. Aniline & Chem. Co., N. Y. C.
Cine Lt. Green	Napthol Green Conc.	White Tar Aniline Corp., 56 Vesey St., N. Y. C.
Cine Green	Acid Green L.	Natl. Aniline & Chem. Co., N. Y. C.
	Wool Green B.	White Tar Aniline Corp., N. Y. C.
Cine Blue	Direct Blue 5B.	Essex Aniline Wks., 39 Oliver St., Boston, Mass.
	Acid Blue GR.	Newport Chem. Wks., 120 B'way, N. Y. C.
Cine Violet	Buffalo Fast Violet B.	Natl. Aniline & Chem. Co., N. Y. C.

The above list of dyes has been selected after testing more than five hundred dye samples, but is necessarily incomplete because new dyes have appeared on the market since these tests were made.

The Eastman Kodak Company is anxious to recommend satisfactory tinting dyes so that if manufacturers will submit samples of new dyes to the Research Laboratory, Eastman Kodak Company, Rochester, New York, they will be carefully tested with a view to recommending those suitable for film tinting.

In cases where alternative dyes have been recommended, they may differ slightly in regard to color, rate of bleeding, etc., and are therefore not strictly interchangeable. This is due to different methods of manufacture. In the following formulæ the first dyes indicated on the above list were used.

The strength of the dyes may vary from batch to batch, the same dyes made by different makers differing particularly in this respect, so that when purchasing it is desirable to secure a statement of the percentage of pure dye in the sample. As stated above, a certain percentage of salt or sodium sulphate is present in most commercial dyes, so that when comparing prices the amount of impurity present should be taken into consideration.

Formulae for Tinting at 65° (F).

TINT NO.	DYE	AVOIRDUPOIS	METRIC	TIME OF TINTING
1	Cine Red	2 lbs.	1000 grams	3 minutes
	Water	50 gals.	200 liters	
2	Cine Red	13 ozs.	400 grams	3 minutes
	Water	50 gals.	200 liters	
3	Cine Scarlet	26 ozs.	800 grams	3 minutes
	Water	50 gals.	200 liters	
4	Cine Scarlet	13 oz.	400 grams	3 minutes
	Water	50 gals.	200 liters	
5	Cine Yellow	18 ozs.	540 grams	3 minutes
	Cine Scarlet	1 oz. 150 grains	40 grams	
	Water	50 gals.	200 liters	
6	Cine Yellow	18 ozs.	540 grams	3 minutes
	Cine Scarlet	1 oz. 150 grains	40 grams	
	Water	50 gals.	200 liters	
7	Cine Yellow	13 ozs.	400 grams	3 minutes
	Water	50 gals.	200 liters	
8	Cine Lt. Green	26 ozs.	800 grams	3 minutes
	Water	50 gals.	200 liters	
9	Cine Green	26 ozs.	800 grams	3 minutes
	Water	50 gals.	200 liters	
10	Cine Blue	13 ozs.	400 grams	3 minutes
	Water	50 gals.	200 liters	
11	Cine Blue	13 ozs.	400 grams	1 minute
	Water	50 gals.	200 liters	
12	Cine Violet	13 ozs.	400 grams	3 minutes
	Water	50 gals.	200 liters	

Method of Preparing the Dye Solution

Dissolve the solid dyes in as small an amount of hot water as possible, and filter through fine muslin. Pour hot water over any residue remaining to insure thorough solution of the dye, and

dilute the solution in the tank to the required volume at 65 degrees (F).

NATURE OF POSITIVE FILM

Only good snappy positive film may be successfully tinted, since tinting tends to reduce contrast.

The depth of the tint obtained depends on the following factors:

1. NATURE AND STRENGTH OF THE DYE-BATH

Except in special cases, such as fire scenes, sunset and moonlight effects, it is very undesirable to employ strong tints, since apart from the displeasing effect and irritation to the eye, the dyes produce a slight softening of the gelatine film when used at 80° (F) in a 1% solution.

Should it be necessary to employ concentrated baths in summer, either cool the dye bath or use a suitable hardener. This will be unnecessary if hardener is employed in the fixing bath after development, but otherwise if formalin (40%) be added to the dye-bath to the extent of 1 volume to 400 volumes of dye solution, no trouble will be encountered. During the winter months when it is advisable to treat all film after developing and fixing with glycerine, the latter may be incorporated with the dye bath, thereby eliminating an extra operation. The strength of the glycerine should be 2%, or two volumes per one hundred volumes of dye solution. In most cases, however, the addition of glycerine considerably retards the rate of dyeing and in order to obtain the same degree of tinting in a given time, the concentration of the dye bath should be increased accordingly.

When delicate tints are employed, the effect is both to remove the contrasting black and white effect, and to add a touch of warmth to the black deposit of silver, even in cases where the highlights are insufficiently stained to be noticeable. The result in many cases is equal to that obtained by partial toning.

2. TEMPERATURE OF THE DYE-BATH.

Although temperature has little effect on the rate of dyeing with the dyes recommended, when used without the addition of acid, it is advisable in all cases to work at 65 to 70° F. to produce uniform results and remove any danger of softening the film.

3. TIME OF DYEING

In order to duplicate any particular tint with a given dye-bath the film may be dyed either by time or by inspection. Dyeing by time is reliable if the dye-bath does not contain acid, though if acid is present, in time the acidity decreases, causing a slowing down of the rate of dyeing, so that it becomes necessary to judge the progress of dyeing by inspection.

If two or more tints of the same color are required, it is better to vary the time of dyeing rather than to vary the dilution of the bath, as a means of reducing the number of individual dye-baths to

a minimum, providing the time of dyeing for the lighter tint is not less than one minute, which time is considered a minimum for the production of uniform results and for complete control of the dyeing operations.

The time of dyeing also depends somewhat on the previous handling of the film. Film which has been fixed in a bath containing ordinary—or chrome alum, dyes more quickly than that created with plain hypo and hardened with formalin.

It is probable, therefore, that small traces of alum, which serve as a mordant for the dye, are left in the film even after prolonged washing.

Should the film for any reason be over-dyed, a small portion of the dye may be removed by washing for 10 to 15 minutes, though the fastness of the dyes to bleeding will permit only slight mistakes to be rectified in this manner.

Life of the Dye-Bath

This averages about 40,000 feet of film per 50 gallons of dye-bath. As the rate of dyeing slows down the bath should be revived by adding a concentrated solution of the dye and not by adding acid. When the bath becomes muddy, especially in warm weather, it should be renewed.

Method of Procedure

Either the "drum" or the "rack" method may be employed, the rack being agitated slightly to insure even dyeing and prevent accumulation of air bubbles, after which the film should be given a thorough rinsing in plain water.

Before drying films on racks it is advisable to set the rack at a slight angle for a few minutes, to enable the surplus water to drain off more readily through the perforations. If drums are used for drying it is advisable to remove the surplus water by whirling the drum previous to drying.

If uniform results are to be obtained, film should never be passed through the projector before either tinting or toning.

How to Obtain Intermediate Tints

Sample tints may be readily obtained by making a trial with a small amount of solution on a short length of film, taking care to match the tint in artificial light and not by daylight.

When matching think of the tint as being made up of one or more of the colors, red, yellow and blue. Colors such as orange are made by mixing yellow and red, violet by mixing red and blue, and green by mixing yellow and blue. Browns are obtained by mixing all three colors, red, yellow and blue.

Local and Multiple Tinting

Very pleasing effects may be secured by locally tinting a portion of the film picture. This can be done either by coloring each picture separately by hand or by cutting a stencil and applying the dye through the stencil by application rollers or by spraying, or a

resist such as a transparent varnish may be applied either by hand or by stencil to those portions which are not to receive dye and the film immersed in the dye solution in the usual way. Multiple tinting is executed in the same way.

Light Transmission

The amount of light cut off from the screen as a result of tinting depends upon the nature of the particular dye, the concentration of dye in the film, and on the purity of color of the dye. An interesting series of measurements recently made in the Research Laboratory of the Eastman Kodak Company show that the screen brightness is diminished by from 25% to 95% as a result of tinting. Excepting in special cases, therefore, it is very desirable to keep the tints as light as possible or at least no deeper than is required to produce the necessary color sensation.

Troubles in Tinting

Streaks and uneven coloring may be caused by:

(a) Grease on the film. Film should never be projected before being tinted.

(b) Excessive bleeding of the dye, allowing the film to stand too long after rinsing and before placing on the drying rack, or insufficient squeegeeing of the film when placing on the drying rack.

(c) Too low a humidity in the drying room. If the air in the drying room is too dry, while the film stands on the rack previous to placing on the drying reel, the edges of the film commence to dry while the center is still moist with water charged with dye which has bled from the film. Even after squeegeeing under such conditions drying marks will be produced and are apparent on the screen as streaks. The remedy is to keep the relative humidity of the drying room around 60% to 70% and to squeegee the film either by means of a blast of air or by chamois as quickly as possible. All drying rooms should be equipped with a recording hydrometer placed in close proximity to the drying reels.

Precipitation of the Dye

This is usually due to the presence of alum, calcium, magnesium or iron salts in the water supply as described above.

Heating and Ventilation of Motion-Picture Theatres

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The solution of the problem of heating and ventilation in theatres may best be understood by analyzing the requirements involved. Ventilation is of vital importance in all buildings, and especially where a large number of people are assembled; and it has been proven conclusively that mechanical means is the only practical, reliable method. Heating necessarily goes hand in hand with ventilation during several months of the year in most localities.

An average person breathes nearly one-half cubic foot of air per minute; the entering air contains 20.9% or more of oxygen and .04% of carbon dioxide; the respired air contains but 16% of oxygen and 4% of carbon dioxide. The normal amount of carbon dioxide in the atmosphere is 4 to 6 parts in 10,000 and, as the proportion in a given volume of air is easily determined, it is taken as a measure of the purity of the air. Carbon dioxide is not directly harmful in itself, but its abundance shows the extent to which the oxygen of the air has been depleted and the air loaded with harmful organic exhalations.

A small diminution of the percentage of oxygen in air impairs its life-sustaining power, and in fact, every breath of air we take is practically exhausted for breathing purposes when it is exhaled. The air on mountain tops and at the seashore consists of 79.1% by volume of nitrogen and 20.9% of oxygen. When the proportion of oxygen falls to 20.8%, a room feels close; even in mines it is rarely less than 20.4%, and at 18.5% candles go out. At 17.2% it is impossible to remain in the air many minutes. Withdrawing oxygen to the extent of 1-500th part of the volume of air reduces the luminosity of a candle by 1-20th. It can then be appreciated why depleted air results in low mental and physical vitality and that the problem of supplying pure air is, under modern conditions, more important than the supplying of food. The more continuous the exposure to bad air, as in schools or theatres, the more serious are its harmful effects.

The usual ventilating apparatus consists of a centrifugal fan, a battery of steam coils, and an air washer which, in addition to purifying the air, adds moisture which is equally as necessary during the winter months as heat itself. In addition to the above, a system of galvanized steel or concrete ducts is required for the proper distribution of the air to the various portions of the building without the possibility of objectionable drafts. A number of states and communities have passed laws requiring a certain volume of air to be delivered into a building for each occupant, usually requiring 30 cu. ft. of air per person. This, in a measure, determines the size fan for any particular theatre or other public building, it being of marked importance to select a fan capable of delivering this air at a comparatively low outlet velocity to prevent the possibility

of objectionable noise. Theatres should be equipped with sufficient direct radiation to maintain a temperature of 70° F. under extreme weather conditions. This is recommended so the temperature in the theatre may be kept above the freezing point at night after closing hours, without operating the fan apparatus. The steam coils used in connection with the fan should only be sufficient to raise the temperature of the air used for ventilation to a temperature of approximately 75° F. under extreme weather conditions. The air washer must be of sufficient capacity to cleanse thoroughly the air, remove dust, soot and other foreign substances, and at the same time partly saturate the air with moisture at a temperature of approximately 42° F. Sufficient steam coils must be placed at the inlet of air washer to raise the temperature of entering air to about 39° to prevent the temperature in the spray chamber ever dropping below this temperature, and thus eliminating the possibility of the spray chamber freezing up. The air after passing through the washer is drawn through the fan, and is discharged over the steam coils, heating it to the temperature of about 75° F. at which it is delivered into the building. The ducts must be of ample capacity to transmit the air to the various portions of the building at a comparatively low velocity to prevent objectionable drafts and noises.

There are two well-known methods of introducing the air into a theatre; first, the mushroom system, and second, the overhead system. With the mushroom system the air is introduced through a large number of small cast iron ventilators placed underneath the seats, there being a plenum chamber immediately below the floor, usually constructed of concrete. These mushrooms must be sufficient in number to keep the velocity down not to exceed 500 feet per minute, and it usually requires one under every other seat in each row. The peculiar shape of these outlets, which resembles the mushroom, gives the system its name. This system is more expensive to install and can rarely ever be adapted to existing buildings without considerable remodeling, and hence, to be used to advantage, should be specified when the building is erected. The big advantage of this system is, that there is a continuous movement of air from the floor to the ceiling from which it is exhausted outside the building by means of large ventilators or an exhaust fan. This immediately removes all bodily heat and exhalations, and the air in the breathing zone is always pure and fresh.

The second method of introducing the air into a theatre is by far the more common and is readily adaptable to an existing building. By this method the air is introduced through ducts placed in the side walls usually built into hollow pilasters and the outlets are placed about 8 ft. above the floor. These outlets are covered with grills and can be made to harmonize with any existing schemes of interior decorations.

The mushroom system is in my opinion the more desirable. It insures uniform ventilation throughout the building without the possibility of objectionable drafts, while in the case of the over-

head system the air must necessarily be blown in at the side walls at a comparatively high velocity to insure any fresh air reaching the central part of the building. Furthermore, it is blown in 7 or 8 ft. above the floor line and must be directed downward in order to reach the breathing zone, and unless the system is scientifically laid out, a large percentage of this fresh air passes out without serving its purpose and there are apt to be stagnant areas in some parts of the building. With this system the foul air is usually removed through vent registers in the walls at the floor line. From there it passes to the attic through ducts in the walls, and discharged outside the building, usually by an exhaust fan.

One point which is very much overlooked is the importance of positive removal of the foul air as the fresh air is introduced. If it is not promptly removed it will mix with the incoming fresh air and again be thrown into the breathing zone, and in a large theatre an exhaust fan placed on the roof or in the attic is recommended. In smaller theatres natural draft ventilators are used. The gallery is usually taken care of by a separate fan or ventilator placed on the roof.

There is no building which should receive more careful attention with reference to proper heating and ventilation than the theatre. It represents one of the most interesting problems for the heating and ventilating engineer to solve. The immense open area, and the large number of people combine the extremes in both heating and ventilating conditions. The rapidly increasing number of motion-picture theatres has caused the fan engineer to give this subject more consideration than in the past. The majority of the patrons at a theatre attend to be entertained, and if atmospheric conditions aren't such as to insure comfort, the patron is apt to become impatient, dissatisfied, and will seek pleasure elsewhere.

Sufficient air at the proper temperature is not the only essential. Humidity is of equal importance with reference to both comfort and health. By humidity we mean, of course, the amount of moisture in the air.

You must appreciate that dryness of air is a relative thing. It has nothing to do with the amount of moisture actually contained as you might suppose, but it depends upon the temperature of the air, as that temperature is related to the actual moisture contents. Remember the quantity of water vapor which the air can hold depends upon its temperature. As an example of what is meant: Suppose the outside temperature is zero. Even if the air is saturated at zero it can hold but a minute quantity of water vapor (½ grain per cu. ft.). If that same air is taken into a building and heated to 70°, its capacity to hold water vapor is increased 16 times.

The outside air at zero, and the inside air at 70° may both contain the same actual quantity of water vapor, but the outside air was saturated, that is, as wet as it could be, while the heated inside air contains but one-sixteenth of the water vapor which it is capable of holding, therefore the inside air is very dry; thus you

can see that the dryness of air is related to its temperature rather than its actual moisture contents, hence the term "relative humidity" which is expressed in percentage. If we say that the relative humidity is 50%, we mean that at the given temperature the air contains 50%, or one-half as much water vapor as it would contain if it were saturated. The relative humidity, therefore, varies as much with the temperature as with the actual quantity of water vapor mixed with the air.

It is quite generally agreed that humidities below 30 are unnatural and injurious physiologically, and tend to reduce the efficiency of the occupants of the building. This is due, first, to the fact that excessively dry air overworks the mucous membrane of the nose and other air passages, and second, because its effect upon the skin or upon the mucous membrane, has an irritating effect upon the nervous system. This has been the experience and conclusion of a great many observers who have investigated the subject. In addition to the bad effect physically, excessively low humidity is objectionable due to its effect upon the furniture, woodwork, pipe organs, etc., which is well known, but perhaps not properly appreciated.

The effect of low humidities is not so serious except where accompanied by comparatively high temperature, but it is necessary to carry a higher temperature in a building where the humidity is low in order to obtain what we might call the necessary sensible temperature which will be referred to a little later.

Another objection to a high temperature and low humidity in any building is that when a person enters the building his clothes are apt to be filled with moist air due to rain, snow or high outside humidity, and with this great amount of moisture in his clothes, he at once feels damp and cold due to evaporation, a very bad combination, the effect of which need not be commented upon further.

There is a corresponding objection to an excessively high humidity. Humidities above 65% are objectionable when accompanied by a room temperature of 70° or more, due to the pronounced soothing effect to which the nervous system is subjected in contrast to the more or less stimulating effects produced by extremely low humidities. High humidities cause a tendency towards lack of energy and even sluggishness. The effect of excessively high humidities is drowsiness, and patrons are apt to enter dreamland during the most interesting part of a film story.

From the foregoing the need of automatic humidity control to prevent either excessively low humidities or excessively high humidities is evident. The air washer as such produces a considerable degree of humidity for the reason that it partly saturates the air which is passed through it, but of itself it does not control the degree of saturation nor the temperature of saturation. In other words, the humidity may be either too high or too low, probably some of the greatest dangers being that the humidity will be too high; the cost of operating excessive, and the conditions of ventila-

tion unsatisfactory. In addition to excessive humidity, especially in the winter months, being objectionable for physical comfort, it takes a great deal of heat to evaporate a pound of water into a pound of water vapor, even without raising the temperature of the vapor above that of the liquid. As an illustration: If the amount of heat necessary to evaporate one pint of water were converted into work, it would lift a man weighing 150 lbs. from sea level to the top of a mountain 5,000 ft. high.

The peculiar thing about dry air is that it must be heated to a much higher temperature to feel the same degree of comfort. Air at 58° F. is comfortable, provided the relative humidity is at least 65%; while if the air is extremely dry, say 30% humidity, it is necessary to carry a temperature of 75° for the same degree of comfort. The best conditions in a theatre would be a temperature of 70° and about 50% relative humidity. You will remember the fine days in early June when you halted just outside the front door, took a long deep breath and started for the day's work with a smile on your face, a wonderful vigor in your stride, a keen, brilliant light in your eyes, and your mind clear. That's not due to Springtime—it's because the temperature is about 70° and the relative humidity 50%.

During the summer months, of course, the heaters are not in use, but the supply fan continues to deliver its full volume of air into the building, and the air washer continues to remove all traces of dust, soot, etc., from the air and often cools it from 10° to 15° by evaporation. The amount of cooling, of course, depends upon the outside relative humidity. If the air is already nearly saturated, little, if any, cooling is obtained, but if the outside air is comparatively dry, as is the case in many parts of the country, there is a very marked cooling even if the water in the air washer is recirculated, as most of this cooling is obtained by evaporation, rather than from the air coming in contact with water at a lower temperature than air. This is generally referred to as evaporative cooling. As an illustration: Moisten one of your fingers and blow upon it—your finger feels cool. Now blow upon one of your dry fingers and there is a warm feeling. When you blew upon your moist finger your breath immediately began to evaporate the moisture. You will remember I referred above to what an astonishing amount of heat is required to evaporate a pint of water. In the summer when no heat is being applied to the spray of water, the air must give up some of its heat in order to evaporate the water. In other words, dry air, greedy for water vapor, is forced to pay for the water vapor with heat; hence the cooling effect when air is passed through a spray chamber. Needless to say the hotter it is outside, the greater the cooling obtainable inside by means of this evaporation. An installation was recently made in Denver, Colo., where the cooling, due to evaporation, was from 25 to 30 degrees below the outside temperature. This would naturally tend to make a theatre a very popular place during the warm months, and a theatre so equipped is due to

be more attractive than the stuffy ones not equipped with mechanical means of ventilating, heating and cooling.

Taking, as an example, a theatre having a seating capacity of 2,000, we find it necessary to install an equipment having a normal capacity of 60,000 cu. ft. of air per minute. This would require a fan measuring about 10 ft. in height, which could be easily installed in the basement of any modern theatre. The power required for delivering the above volume of air would not exceed 12½ H.P. The air washer should have a clear area of about 120 sq. ft., approximately 10 ft. high, 12 ft. wide, and it would require a centrifugal pump with a 7½ H.P. motor for recirculating this water and delivering it to the spray nozzle at the required pressure. The same water is usually recirculated and only sufficient fresh water added to replace that evaporated by the air.

The tempering coils placed at the inlet of the washer should be capable of heating the air from, say zero to a minimum temperature of 39° F., and would require a total of about 3,000 feet of 1-inch pipe. The total condensation in these coils per hour with an outside temperature of zero would be about 2,500 lbs. of steam. The necessary heat ejected into the water used in the spray nozzles of the air washer would be about 1400 lbs. per hour. This heat would only raise the temperature of the air from 39° to 42° F., about 80% of it being required to evaporate the water used for partially saturating the air. The re-heater coils should increase the temperature of the air from 42° to 75° F., and should contain about 3,400 feet of 1-inch pipe, and the condensation would be about 2,300 lbs. per hour, so the total amount of steam required per hour for a theatre of this size would be approximately 6,250 lbs., corresponding to 180 H.P., but as zero conditions do not exist many days throughout the year, 150 H.P. boiler arranged properly for carrying a slight overload would be of ample capacity.

The centrifugal pump for recirculating the water in the air washer and spray nozzles should handle a total of about 320 gallons per minute against a pressure of approximately 30 lbs. per sq. in.

If an exhaust fan is placed in the attic or on the roof for removing the foul air, it should have a capacity of 45,000 cu. ft. per minute. Since the supply fan delivers 60,000 cu. ft. to the building, it has been found that nearly 25% of this amount escapes by means of leakage around doors, windows, etc., there is a slight pressure in the theatre above the atmospheric pressure. An exhaust fan capable of handling this volume of air would require only 5 H.P. The approximate cost of such a system, consisting of supply fan, tempering coils, air washer, re-heater coils, centrifugal pump and attic exhaust fan, together with necessary motors and galvanized iron distributing pipes and mushroom ventilators, based on the mushroom system, should not exceed $12,000.00. This includes cost of installing the equipment, but does not include the boilers.

At first thought this may appear high considering that direct radiation must be used in addition, but the advantages such an

installation gives a theatre can scarcely be over-estimated. The increased patronage due to favorable climatic or atmospheric conditions will pay for the apparatus many times in a single year, while the life of the equipment is easily a quarter of a century.

The Various Effects of Over-Speeding Projection

By F. H. Richardson

Paper designed to cause discussion—Effect of overspeeding on projection mechanism—Over-speeding has a tendency to aggravate the evil of oil on film—Makes picture unsteady—Has bad effect on film sprocket holes—Alters speed of motion of moving objects in screen picture and injures artistic effect—Affects the music rendition—Has one beneficial effect.

That speed of projection which will produce absolute naturalness of action of moving objects in the screen picture is the speed which will cause precisely the same film footage to pass the projector aperture per minute as was passed over the camera aperture in the taking of the scene being projected. This is, I think not a subject for argument, but merely a statement of known fact.

The Society of Motion-Picture Engineers, has, in its wisdom, seen fit to establish as normal speed of projection, i. e., that speed which will cause sixty feet of film to pass over the projector aperture per minute. This action presumably was founded on the presumption that "taking" (camera) speed would also be at the rate of sixty feet per minute. Presumably it was expected by the society that the projectionist would vary his speed of projection either above or below normal when it became necessary by reason of variation in "taking" (camera) speed to do so in order to produce naturalness of action of various objects in the projected picture.

Personally, the writer may and does disagree with the wisdom of adopting sixty feet as the projection speed standard, believing a somewhat higher rate of speed better calculated to synchronize with modern camera speed, and to avoid the flicker tendency which is present under modern practice which involves high screen brilliancy; but that is beside the point.

This paper is designed to set forth for your consideration those various effects which result from the over-speeding of projection, but let it be clearly understood that insofar as applied to moving objects in the screen picture, over-speeding can only be considered as taking place when projection speed is greater than was the speed of the camera which took the scene; also that the various effects hereinafter described will be of small or great in exact proportion of the variation of projection speed from normal, or, in case of screen action, from camera speed. The paper has, also, as one of its chief objects the stimulation of study and discussion of the whole subject of projection over-speeding and its effects.

Effect on the Projector Mechanism

First let us examine into the effect of over-speeding on the projector mechanism itself. We may fairly assume that the engineers who designed projection mechanisms based their calculations as to the effects of abrasions, strains and stresses that moving

parts would be called upon to withstand, upon what those abrasions, strains and stresses would be at normal speed of projection, with, of course, the usual allowance for occasional temporary overload (excess speed), just as designers of electric generators base their calculations on normal load, with allowance for occasional temporary overload. It is a well-known fact that a properly designed and constructed electric dynamo will give its maximum service at normal full load, and that it will not be appreciably injured by an occasional overload, up to even as much as one hundred per cent, provided such overload does not extend over more than a brief, stated period.

Practically exactly the same thing is true of the projector. Modern projector mechanisms will give astonishingly long, efficient service when used at normal load (which in their case means normal speed) provided there be intelligent care, lubrication and proper adjustment of the tension pressure upon the film at the aperture for that speed. It is also true that the mechanism will not be materially injured, or have its working like appreciably shortened by occasional temporary excess in projection speed, even though the excess be as much as one hundred per cent.

If, however, we place an electric generator under constant heavy overload, or maintain periodic heavy overload for too long periods of time, serious damage will inevitably result, which may and most likely will very greatly shorten the life of the machine as a whole, and most certainly will work serious injury to, or even cause the complete destruction of its vital working parts.

Precisely the same thing is true of the projector. Excessive speed subjects all moving parts thereof, but more particularly the somewhat delicate high-speed parts, to a strain they were never designed or intended to withstand.

We have cited the analogy of the electric generator by reason of the fact that it is one with which we are all, we think, reasonably familiar.

The foregoing is perhaps not sufficiently detailed to be entirely convincing. We will therefore examine into the matter somewhat more minutely. At normal projection speed (sixty feet of film per minute) the projector intermittent movement acts at the rate of sixteen times per second, each time causing the delivery by the actuating cam pin, or diamond, upon the star or cross, what amounts to a sliding hammer blow, of sufficient force to start the intermittent sprocket and shaft revolving, against the inertia of the parts, plus the friction of the bearings and against the inertia of about six inches of film, plus the constantly exerted braking friction of the tension shoes upon the film, all of which is, you will realize, a not inconsiderable force to overcome, even under the very best conditions possible. Yet at normal speed this must be done at the rate of 960 times per minute, and the movement must, after being brought to maximum speed, be again slowed down to an absolute stop an equal number of times.

If we increase the projection speed to one hundred feet of film

per minute this movement is increased to 27.66 per second, or 1,599.6 per minute and if we still further increase projection speed to 120 per minute it reaches the enormous total of thirty-two per second, or 1,920 per minute. Think of it! Thirty-two times per second the intermittent must start its mechanism and several inches of film, against the pull of the various forces before enumerated, from dead still bring the parts to high speed and again stop them to absolute stillness. And this must be done by comparatively light mechanism, which must be, and remain absolutely mechanically true (absolutely) in the ordinary meaning of that term. There is nothing actually "absolutely mechanically true," if it is to give a perfectly steady picture on the screen.

In considering this matter, it is well to remember that the normal speed of a twelve-inch circular saw is less than two thousand revolutions per minute. The speed of the armature of electric generators, except small, high-speed generators, does not nearly reach nineteen hundred per minute. It therefore follows that at a projection speed of 120 per minute the intermittent movement is taking place at a speed greater than the normal speed of a twelve-inch circular saw, or the normal speed of the armature of the electric generator.

It should require no unusual powers of discernment to understand what the ultimate effect of such a terrific strain will be, if long continued. It cannot but result in the very great shortening of the life of the mechanism, and the rapid breaking down of its accuracy of function.

It is quite possible there are those who do not realize the frequency with which over-speeding is practiced in theatres. For their benefit I will say that hundreds upon hundreds of theatres, or so-called theatres at least, make it their regular practice to project a thousand feet of film in as little as eight minutes. Other hundreds do the same thing at certain "rush hours" of the day, either every day or on certain days of the week. Eight minutes to the thousand feet of film is at the rate of one hundred and twenty-five feet per minute. It is a deplorable fact that even some large, otherwise high-class theatres make it their habitual practice to project at the rate of from ninety to a hundred feet per minute.

The resultant damage to film and machinery is directly in proportion to four things, viz.: (A) The amount of excess speed. (B) Amount of braking power the tension shoes exert on the film. (C) Condition of the mechanism and (D) Lubrication of the Mechanism.

It is a well-established fact that the exhibitor who abuses his projectors by over-speeding, almost invariably blames their consequent shortness of life and the excessive repair bills upon faulty construction of the projector itself, instead of upon the abuse to which he has caused it to be subjected.

Oily Film Traceable, in Part, to Over-Speeding

Another evil the motion-picture industry is called upon to bear which, while not entirely due to over-speeding, is nevertheless greatly

augmented thereby, is oil on the films. If we examine the films in any exchange we will be reasonably certain to find seventy-five per cent of them carrying oil to some extent. A goodly share of this percentage will carry considerable oil, while some films will be literally smeared with it.

This state of affairs is traceable to several causes, but it is a condition always greatly aggravated by over-speeding, partly because of the natural inclination to over-oil a mechanism which is working under heavy stress, and partly by reason that as speed of rotation of revolving parts increases there is added tendency to throw off oil by centrifugal force, and much of which finds its way, eventually, to the film.

UNSTEADINESS OF THE PICTURE

Is always greatly aggravated by any considerable excess in projection speed above normal. This is due to several causes. First, there is the rapid wear of mechanism parts, which very naturally makes for lost motion and unsteadiness of the picture. Second, there is increased tendency to wear off intermittent sprocket teeth, due to added strain of excessively tight tension required for high speed, and worn intermittent sprocket teeth always make for unsteadiness in the picture. Third, there is the added tendency to jump when a badly made splice hits the upper end of the tension shoes. In addition to this there is, to some extent, additional vibration of the machine as a whole, which of course to some extent make for unsteadiness of the picture on the screen.

I feel there is no need to further elaborate on this phase of the subject. It should, it seems to me, require no argument to convince even the most skeptical that excess in projection speed makes for unsteadiness of the picture on the screen, nor can the fact that it is possible to project a steady picture at high speed be accepted as proof or even as evidence to the contrary.

EFFECT OF OVER-SPEEDING UPON THE FILM

One of the important functions of the projectionist is to see to it that the tension springs exert just sufficient pressure upon the film to accomplish the purpose for which they are intended. But the amount of pressure (tension) necessary to stop the film after the intermittent sprocket has ceased to act and to hold the parts in retard, will depend in large degree upon the speed of projection, since the braking action of tension shoes upon the film has entirely to do with overcoming the momentum of the film and holding the intermittent sprocket in retard when the movement ceases to function. It therefore follows that decidedly less tension will be required at normal speed than at high speed, and that, always assuming the tension to be adjusted to the actual requirement, the strain upon the film sprocket holes, the teeth of the intermittent sprocket and the whole intermittent movement as well as the various gears of the mechanism will be greatly increased by increased speed of projection; also that the added tension made necessary by increased projection speed will produce abnormal wear upon the aperture plate tracks, as well as aggragate any tendency of emul-

sion to deposit upon the tension shoes, and to increase the tendency of such deposit to do serious damage to the film.

In connection with the foregoing we must call attention to the fact that by proper construction it is possible to so support the film in its path between the upper end of the film gate and the intermittent sprocket that the film itself will in some measure act to reduce the amount of tension necessary; also that closeness of intermittent sprocket to aperture, and the holding of the film in firm contact with the intermittent sprocket has some bearing on the amount of aperture tension necessary for a given speed.

Before closing this phase of the subject let me cite, in proof of the strain under which the intermittent mechanism of a projector and the edges of film sprocket holes work, the following facts.

So great is the pull of the film upon the intermittent sprocket teeth that even though the teeth be of the finest grade of steel and hardened as much as possible, still the film cuts or wears away the metal in a comparatively short time. In considering this fact as applied to the total amount of pull exerted upon the film, as against its almost negligible inertia plus the braking power exerted by the tension springs, let it be remembered that there are eight of the intermittent sprocket teeth contacting with sprocket hole edges at all times. I think you will agree with me that when the pull is so great that glass-hard steel is cut away from eight teeth at the same time, and the cutting is done by a celluloid sprocket hole edge six one-thousandths of an inch in thickness, and that those sprocket hole edges are contained in a film having considerable money value, the reducing of the pull on the intermittent sprocket-teeth to its lowest possible value is an important item, while increasing it needlessly is a very serious matter indeed; that over-speeding does increase it, always presuming to be reduced to its necessary value for normal speed, cannot, I think, be seriously questioned, though, as before remarked, there may be a less percentage of increased tension pressure for a given increase in projection speed in a mechanism in which the film is well supported in its passage through the film gate, and where the distance from intermittent sprocket to aperture is short. Such claim is made, and it seems reasonable, though the author has made no actual test of the matter.

Summed down, we find that with normal projection speed as against over-speeded projection, there is decidedly less wear of the projection mechanism, intermittent sprocket teeth, film sprocket hole edges, aperture plate tracks, and tension shoes, as well as less tendency for deposit of emulsion on the tension shoes, and less liability of such deposit to do serious damage to the film. We find, also that wear of intermittent movement, gears, bearings and intermittent sprocket holes and sprocket hole edges increases very rapidly with increase in projection speed, as also does tendency to over-oil and the throwing off of oil from moving parts.

Just what the actual damage due to over-speeding projection as expressed in dollars and cents, it is impossible to say, for the reason that no reliable figures are available as to the actual number of feet of film in daily use, the average value per reel of the film in daily use, or the average percentage of damage done to each reel. The writer has himself placed the probable number of reels in daily use in the United States and Canada at 120,000, but the actual figure may be either more or less. From long and intimate association with matters pertaining to projection we believe we are able to form what may be termed a reasonably intelligent idea of such matters. If we accept the number of photoplay theatres in the United States and Canada (16,000) as approximately correct, and assume the average daily program to consist of seven reels, we then have a total of 112,000 reels of film in daily use. If we then, taking new and old together, estimate the average money value of these reels of film at $50.00 cash we will have a total of $5,600,000 as the cash valuation of film in daily use in theatres of the United States and Canada. These figures, while admittedly somewhat in the nature of a guess, will, we believe, err, if at all on the side of conservatism. However, in order to be entirely safe, let us arbitarily subtract from the total the sum of $2,000,000 leaving $3,600,000 as the actual cash value. With these figures before us it requires but a glance to see that, even with the above ultra-conservative estimate of valuation, any considerable percentage of unnecessary damage to film is a very serious matter indeed. Even so infinitesimal an amount (in percentage) as one-tenth of one per cent. of unnecessary damage would reach the respectable sum of $3,600. The personal opinion of the author is that unnecessary damage to film traceable wholly to overspeeding will reach the least one-fourth of one per cent per day, and one-fourth of one per cent is, based on the above estimate of valuation, $9,000. Bear in mind the fact that any damage done to film or to machinery must inevitably be absorbed in the "overhead" of the industry, and that part having to do with film ultimately be charged back to the exhibitor in the form of increased film rental, because in the last analysis every item of expense incurred by the industry, no matter what its form, must be paid for out of box-office receipts, since the industry has no other source of income. Please understand that in the foregoing estimate of probable damage we firmly believe ourselves to have been ultra-conservative—that the actual figure is very much in excess of that named.

In addition to the foregoing we must not overlook the fact that there are not less than 25,000 projectors (probably a substantially larger number) in use in theatres of the United States and Canada. These machines probably cost exhibitors an average of not less than $400 each, or a total of $10,000,000, and if their average life be shortened through abuse in over-speeding by as much as ten per cent., it will be seen that additional serious overhead expense is incurred by the industry, since 10% of $10,000,000 is $1,000,000.

It will, of course, be understood that the values quoted are arbitrary. They are based merely on what the writer believes to be

probable after many years devoted to the study of projection practice. The actual amount of damage may be either more or less. But that damage of considerable amount results to both film and projection machinery through over-speeding will be generally admitted by every one in the least conversant with projection practice I have no doubt. The main intent of this paper is to call attention to the matter in a way which will cause further investigation, rather than to quote exact values of damage actually done to film and machinery.

What Happens to the Music

Another effect of over-speeding projection is to speed up the music, and thus very often ruin its artistic effect. This, however, acts, both ways, because as a matter of fact, unless there be very careful selection of music which will synchronize with projection, it may be found that the projection of some scenes at normal speed will act to slow down the music and thus injure, if not ruin its effect. In the foregoing we assume that there is a certain definite relation between tempo of music rendition and tempo of screen action, and that in most instances the two must agree unless one or the other is to suffer.

Injury to Screen Action

But, after all, by far the greater damage due to over-speeding projection is found in the injury to the action of the photoplay itself. This one thing has, we venture the assertion, done more to render difficult the popularization of the photoplay as a high class form of theatrical entertainment than any or all other causes combined. It has tended to cheapen the photoplay and to prevent its drawing at high prices, except where some story of extraordinary power, supplemented by wonderful scenic effects, has offset the unnaturalness caused by high speed, or where the screen has been supplemented by added attraction.

The industry pays literally high sums to individuals to enact the principal roles in photodrama. This is by reason of the fact that these "stars" have established a "drawing power." In examining into what constitutes this drawing power we are certainly justified in assuming its main foundation to the ability to portray the character artistically. Who will dispute this? And if that be the fact, then does it not follow that their rendition could hardly be improved upon by so ordinary a person as a theatre manager or a projectionist, or even by the producer himself? That much is hardly subject to argument. It may be accepted as fact; and if it is fact, then it naturally follows that the artistic rendition for which huge sums were paid to the artist may only be reproduced on the screen when projection is at precisely the speed at which the camera "took" each individual scene. That, too, is fact, is it not? If the tempo of projection be speeded in any degree above speed of "taking," the effect, insofar as relates to moving objects on the screen, is altered, and the alteration is in exact proportion to the excess of projection speed over "taking" speed.

If the actor enacted a death-bed scene artistically, which was

photographed at sixty per minute, and same scene be projected at ninety, the action of the artist is changed into quick, jerky movements, which convey to the audience an entirely different impression than would have been conveyed had the scene been projected at taking speed. The death-bed scene is still a death-bed scene, true, but into it has been injected an element of the ludicrous, which has the effect of intermixing its solemnity with farce comedy. "Pep" is all very well and highly commendable in its place, but, when pall-bearers are made to come out of the house at something between a trot and a lock-step gallop and to dump the coffin into the hearse with a zip, we believe the "pep" thus displayed is misplaced. Certainly the screen gains nothing by such an absurd speeding up of its action.

It must be noted, however, that there are occasional exceptions where a scene may actually be improved by moderate over-speeding of projection. Such scenes are, however, rare. As a rule they are those where speeding automobiles are involved, with no animate figures other than those in the machines. Such scenes merely form the exception which proves the rule.

In over-speeded projection the film story may carry itself, but it is nevertheless an unnatural, weird and ofttimes entirely absurd performance, which is anything else under Heaven than satisfactory. It gives the effect of unrealness, thus keeping constantly in the subconscious mind of the audience the thought that it is looking at a mere picture, whereas with action at normal speed, with attendant naturalness, it is not at all unusual for the audience to become sufficiently lost in the action to forget the screen and actually live in and with the play.

The author ventures the assertion that over-speeding of projection, as applied to its effect in the alteration of action of moving things on the screen, with resultant effects on the minds of photoplay theatre patrons, is the one worst enemy with which the industry has to contend.

It is not within the province of this paper, which is already too long, though there is ample material for many more pages, to enter into detail as to the causes of over-speeding. They are many, but chief among them is the desire of theatre managers to "run to schedule," which means the allotting to each show a certain number of minutes, regardless of variation in film footage or musical or vaudeville numbers, and the desire to crowd into those minutes a program which can not be properly handled in the allotted time. The average theatre manager seems to consider a reel of film as standing for a certain number of minutes of show. This would be entirely true if

(a) All reels of film had the same footage, and
(b) All cameramen photographed all scenes at precisely the same length;

but films vary widely as to footage, while camera speed is almost anything else but standard. That is cold fact, and never will the screen come fully into its own until it is so recognized and pro-

jection placed in the hands of capable men who can and will compensate for difference in camera speed often as between adjoining scenes, thus producing complete naturalness of action on the screen, or until camera speed be absolutely set at one unalterable standard of footage per minute. This latter is, however, not likely to become an actuality by reason of wide variation of light strength encountered by cameramen, particularly when out on "location."

THE ONE SINGLE BENEFICIAL EFFECT OF OVER-SPEEDING

Is found in the fact that it tends to reduce or eliminate any flicker tendency there may be at normal speed.

The Eccentric Star Intermittent Movement

By Willard B. Cook

The primary mechanical essential for motion-picture projection is a suitable means for advancing the film, picture by picture, between the intervals that successive pictures remain stationary for the purpose of registering their image upon the screen.

To produce the intermittent movement of the film, hundreds if not thousands of mechanical movements have been invented or applied.

Among the earlier successful forms of the intermittent movement were the beater, which consisted of a roller on a crank. This operated in the lower loop between the aperture and the take-up sprocket. During the working portion of its stroke, this roller exerted sufficient pressure on the lower loop to pull down one picture length past the aperture, where it remained stationary until the next revolution of the roller, the objections were its noise and injury to the film.

The harmonic cam, actuating a claw which engaged the perforations of the film, was applied by Lumiere and with slight modifications is used extensively in cameras today although for projectors its use has been nearly abandoned. It has two disadvantages, slow speed and concentration of wear upon a few perforations, instead of distribution over a number of them.

For some years the Maltese Cross, or, as it is better known, the Geneva Star and Cam intermittent movement has enjoyed great popularity and is used by most of the leading projector manufacturers today.

In its best known form it is shown in Fig. 1.

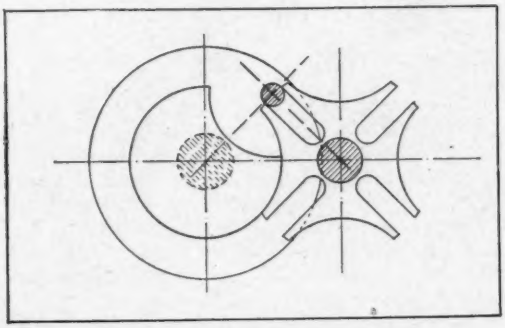


Fig. 1.

It is quite evident that during each continuous revolution of the cam pin, the star will be rotated one-quarter of a revolution. Also that this intermittent movement of the star will occur during only one-quarter of the revolution of the cam and that the star will

remain stationary during the other three-quarters of the cam revolution. This is called a 90-degree cam action.

Place a sprocket on the shaft of the star, with a diameter and teeth to fit four successive pictures to its circumference and you have the common "three-to-one" projector intermittent movement.

As the movement of the film must be masked by the shutter, it is evident that, if the film could be moved more quickly, its stationary image could be correspondingly prolonged on the screen, thus increasing the proportion of the illumination and enhancing the realism of the picture.

Obviously, this can be accomplished by increasing the diameter of the cam and thus decreasing the number of degrees during which the pin is turning the star.

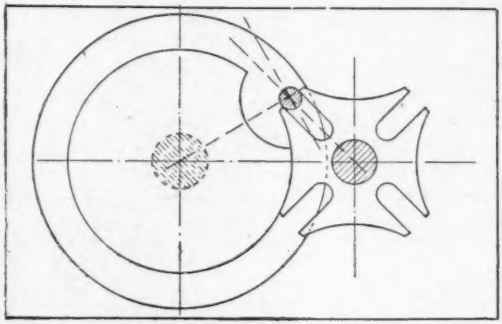


Fig. 2.

This is shown in Fig. 2 which illustrates one form of a "five-to-one" intermittent movement with a 60° cam action.

But note that the pin no longer enters the star slot on a tangent to its travel. Instead, it strikes the side of the slot violently, at an angle of about 15°, which starts the star (and with it the sprocket and film) with a jerk, destructive alike to the mechanism of the machine and the perforations of the film. Such an intermittent movement is subject to rapid wear, besides wearing out the film quickly.

Now, suppose that instead of making the slots in the star radial, they be inclined obliquely in such a manner that the axis of the slot coincides with the tangent to the course of the cam pin at the instant of its entrance.

Fig. 3 illustrates such an eccentric star intermittent movement having a cam action of 60°, or another form of a "five-to-one" movement.

This movement, like the ordinary Geneva Movement, with radial slots shown in Fig. 1, starts the film slowly, without shock or strain on either the mechanism or the film perforations.

But in other characteristics the two movements are surprisingly different, and the eccentric star develops a number of marked projection advantages.

FIRST: On account of the obliquity of the slot, the film starts

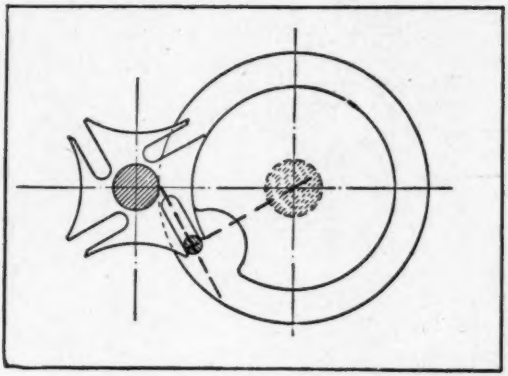


Fig. 3.

more slowly than with the radial slot and its early acceleration of velocity is less. This is of great importance in prolonging the life of the film as the strain on the perforations is greatest in starting the film from a period of rest.

SECOND: The period of acceleration is prolonged to beyond the middle of the movement. At the middle of the cam action the film has been advanced only one-third of a picture length.

THIRD: The prolongation of the period of acceleration is accompanied by a corresponding shortening of the period of retardation. This is of advantage in that the friction of the pressure plate or tension springs in the film gate naturally assists the intermittent sprocket to bring the film to a full stop.

It must now be evident to the observer that whereas other rapid intermittent movements wear out both themselves and the film, the eccentric star intermittent movement conserves the life of the film even beyond that of the slower radial star intermittent movement of 90° cam action. Actual life tests confirm this theoretical analysis.

FOURTH: It has long been an accepted principle that, with any ordinary intermittent movement, the interrupting or "travel" blade of the shutter must have approximately the same angular area as the action of the cam, plus the additional area necessary to cover the light ray completely before and after the actual movement of

the film. A few degrees on each edge of the shutter blade can usually be trimmed off, because the persistence of vision of the human eye is so poor that the travel ghost due to the slow movement of the film during the beginning and the end of the period of film travel can not be detected.

Thus with a three-to-one intermittent movement a travel blade of 85° to 90° is usually furnished. By the same rule the five-to-one intermittent movement of symmetrical action, like Fig. 2, requires a travel blade of about 60°.

But with the five-to-one eccentric star intermittent movement, as illustrated in Fig. 3, the movement of the film is so slow during the first part of the period of the film travel that it is not perceptible to the human eye and about 15° can be trimmed from the leading edge of the travel blade of the shutter, thus permitting a 45° travel blade without perceptible travel ghost at normal projection speed.

It thus becomes obvious that this movement permits the use of the long desired ideal shutter of minimum flicker, viz.: that of three equal area blades (45° each) separated by three equal openings (75° each). In other words, 62½ per cent of the light from the objective is transmitted to the screen, without the flicker inseparable from the use of any shutter with unequal blades.

Briefly summarizing, the eccentric star intermittent movement makes possible for the first time:

(a) Rapid movement without injury to the film.
(b) Greatly increased illumination.
(c) A 45° balanced shutter, eliminating all flicker.

Standards in Theatre Design to Safeguard from Fire and Panic

By William T. Braun, *Architect*

The adoption of standards in the design of theatres, to safeguard the public from fire and panic, is a subject which is worthy of consideration by a society interested in standardizing the various parts of the industry.

The design from an esthetic standpoint varies considerably with the size of the house, location, amount of money to be spent, the architect's ability, the owner's ideas, etc. Therefore, this paper will not discuss this phase of the subject. There are, however, many points in the design and construction of theatres that should and can easily be standardized for the safety of the theatre-going public. This and the following reasons have prompted the preparation of this paper.

After every great theatre fire in which there has been a great loss of life, there is considerable agitation on the part of officials and the public in general, to try to prevent a repetition of the disaster. The usual result is the drawing of more stringent building ordinances and restrictions, but the general public soon forgets, inspectors become lax, and the laws are not enforced. Although there have been no great theatre fires within the last few years, constant vigilance and agitation by officials and those in a position to suggest will lessen the chances of a holocaust. Also in the smaller cities and towns which at present time support large theatres, there is an absence of carefully drawn building ordinances regulating theatre construction in so far as the safety of the audience is concerned. In fact, in many fairly large cities, there are no regulations whatever, concerning even the most important safeguards. The safety of the patrons is then in the hands of the architect and owner. The architect may not be sufficiently familiar with the many details of this specialized form of building and their great importance, or the owner may, in his desire to cut the cost of the building or to increase the seating capacity, overcome the objections of his architect, endangering the safety of the public. Again, in some towns, there still exist many ordinances that were drafted when the actual dangers of the cinematograph were greatly magnified by men who had little knowledge of the actual conditions. The ever-increasing popularity of the theatre must not be allowed to suffer from accidents due to improper construction or regulation thereof, and the Society of Motion Picture Engineers would do well to recommend these or other similar standards to safeguard the industry where no local regulations exist.

Before discussing these standards let us briefly review, in a general way, how the loss of life usually comes about in a theatre fire and what means and safeguards should be employed to insure the safety of the audience. By so doing, we can tell why the requirements enumerated below should be rigidly adhered to.

In the hundred years (1797-1897) at least 9,355 persons lost

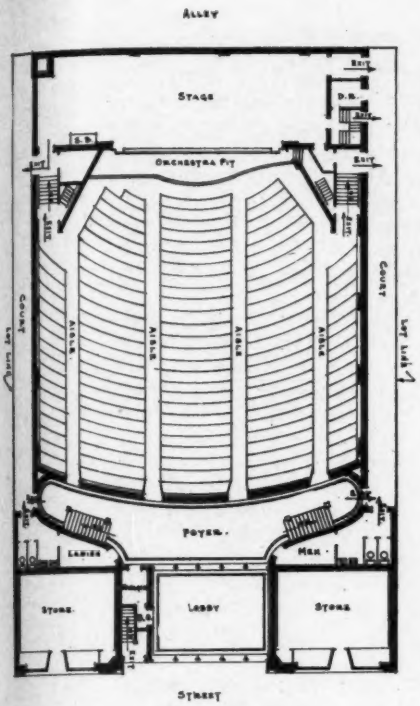


FIGURE 1

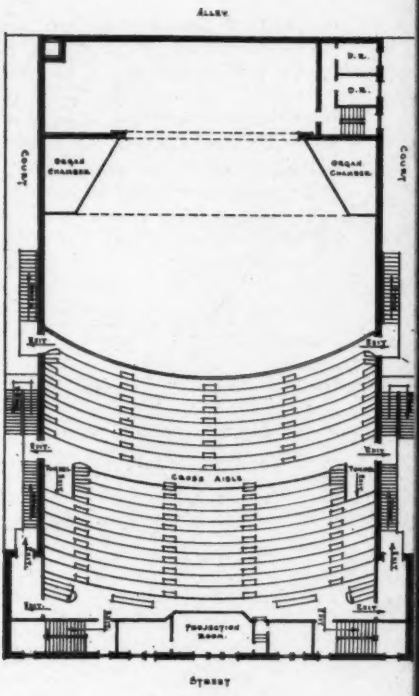


FIGURE 2

their lives in theatre fires, according to William Paul Gerhard in his book on "Safety from Fire and Panic in Theatres." About 14 per cent of these fires broke out while an audience was in the building. In the greater number of fires the loss of life has resulted from the rapid spread of flame on a stage covered with scenery, followed within two or three minutes by an outpouring of suffocating smoke through the proscenium arch into the top of the auditorium, before those in the balconies and galleries could escape. In this way many people in the galleries lost their lives by burning, suffocation due to heat, smoke, fire gases, by shock or fright, and by the crush or jam of the panic in which many were trampled to death; most of this happening within five minutes of the first flame.

In the few fires which have occurred in theatres without a stage and used for the presentation of motion pictures only, the loss of life has occurred by the burning film instead of stage scenery, but the fear and results of panic are the same in any public gathering.

Therefore, the chief considerations for safety of the audience are: Removal of smoke and fire gases accomplished by the quick

opening of ample automatic smoke vents on the stage or in the projection room; the equipment of the stage and other hazardous rooms with automatic sprinklers to smother the flame; the confining of the fire to the stage by means of a fire-resisting curtain at the proscenium opening or the closing of portholes of the projection room by fire shutters, sufficient light supplied by emergency controlled lights, as darkness leads to confusion, struggle, etc.; ample exits, stairways and passages to the main floor and exterior courts, to permit of quick escape of the audience; and fireproof construction to retard the progress of fire.

In the preparation of this paper, the ordinances regulating the construction of theatres in Boston, Chicago, Los Angeles, New Orleans, New York, Philadelphia, San Francisco, Seattle and St. Louis were reviewed and tabulated, as well as the recommendations of the National Board of Fire Underwriters. The standards recommended in this paper are a conclusion or summary of these regulations and are presented in section form, each part of the building covered in a separate section.

As the great majority of theatres now being built are of a larger seating capacity than 300 and most of them have a stage, it will be advisable to limit our discussion to this type. However, in Chicago and in some other cities, there is a special class for theatres over 300, but less than 1,000 seating capacity for the exhibition of moving pictures only, no stage being permitted, and for this type the standards recommended for the balance of the building should be strictly followed.

Section 1. Buildings Included

Every theatre or other building used for the presentation of motion pictures, theatricals or for public entertainment of any kind and accommodating more than 300 persons shall be built to comply with the following sections. These requirements shall apply to every building hereafter erected and to any building remodeled for the above purpose and shall govern the planning and construction whether a stage is provided for or not.

Section 2. Frontages

Every building covered by the above shall have frontage at least on one street. Where the building is not on a corner lot it shall have an open court or passageway on each side of the auditorium extending from the proscenium wall to the street in front. Or, in case there is a street or alley at the rear of the stage, such passage may extend from the foyer to such street or alley. (See Fig. 1) Where a building is on a corner lot and one side of the auditorium fronts on the street or an alley, the passage may be omitted on this side. In a building used for the presentation of motion pictures only, having no stage and all seats are on the main floor, it will be permissible to omit the courts or passage on the sides of the auditorium, provided that there is no cross aisle and there are not more than twenty-five rows of seats and that direct exits shall be provided at both ends of each aisle of such capacity as provided in Section 10, and leading

into street at front and street or alley in the rear. Courts or passages shall be of width provided in Section 11.

SECTION 3. CONSTRUCTION

All buildings of this class and buildings built in connection shall be of fireproof construction throughout, except as follows: Steel of the gridiron shall not be fireproofed. Roof trusses of steel need not be fireproofed unless there is a building over the auditorium, but they shall have a suspended ceiling of metal lath and plaster under them. The steel supporting removable floor traps in the stage floor need not be fireproofed.

SECTION 4. BUILDINGS IN CONNECTION.

Any building built in connection with the theatre shall be of fireproof construction throughout. The building shall be separated from every part of the theatre with a solid masonry wall of thickness required for the main walls of the building. Any part of the building over the auditorium or entrances shall be separated by a fireproof floor. No structure of any kind shall be permitted over the stage. If the theatre is used for presentation of pictures only and there is no stage and all seats are on the main floor and no part of connecting building is over three stories in height, such connecting building may be of ordinary construction, providing it is separated from the theatre as above specified. Buildings in connection with the theatre shall not be used for factory, warehouse, lodging house or for any hazardous purpose.

SECTION 5. SEPARATION OF AUDITORIUM

There shall be a fireproof wall between the auditorium and the foyer, lobby, corridor or any room forming part of the theatre in each tier. Openings shall be permitted only at the end of aisles and shall be protected with self-closing fireproof doors. This shall not apply to motion-picture houses only, as covered in Section 2. The capacity of all foyers, lobbies or passages shall be equal to 1½ sq. ft. for each person accommodated on that tier.

SECTION 6. FLOORS

The auditorium and balcony floors, as well as the floors of all foyers, lobbies and corridors, shall be designed to carry a live load of 100 lbs. per sq. ft. Floors may be either of concrete or other incombustible material or of wood on sleepers imbedded in concrete. Floors at exits shall be level and flush with adjacent inside floors and shall extend for an unbroken width of not less than four feet in front of each exit.

SECTION 7. SEATS

Seats shall be placed not closer than 32 inches back to back. Seats shall be firmly secured to the floor. There shall not be more than six seats between any seat and an aisle.

SECTION 8. AISLES

Aisles with seats on both sides shall not be less than 34 inches wide at the proscenium end, those with seats on one side only 30

inches at proscenium end and all aisles shall increase in width one inch per five feet toward the exits. Unless direct exits are provided at the end of each aisle on the main floor, there shall be a cross aisle every fifteen rows connecting to a direct exit, leading to the outside court or passage. There shall be a direct exit by tunnels or a cross aisle leading to tunnels and emergency exits every 12 feet in the height of the balcony. (See Fig. 2) Platforms in the balcony shall not be higher than 21 inches and shall have a minimum width of 32 inches. When the rise of seat platform is less than 4 inches per foot, floor of aisle shall be made as a gradient. When steps are used in the aisles, risers shall not be more than 8 inches high and treads not less than 10 inches wide. The width of tunnels in the balcony shall be equal to 20 inches per 100 seating capacity that they control but they shall not be less in width than the aisle leading to them nor less than 4 feet wide.

SECTION 9. ENTRANCES

The width of the main entrance doors and the lobby shall be based on 20 inches for each 100 seats provided. No entrance shall be less than 15 feet wide. There shall be a separate entrance from the street for each gallery or balcony over the first balcony. The floor at the main entrance shall be at the sidewalk level. No auditorium shall have the highest part of its main floor more than 3 feet above the level of the sidewalk at the entrance. All doors in the entrances shall open out in a recess in the wall so as not to block the passage when open, and no doorway shall be less than 5 feet wide. There shall be at least two entrances or exits to every tier accommodating 300 or less, and at least three entrances to every tier between 300 and 500. Over 500 capacity there shall be added 20 inches for each additional 100 seats, to the total width of entrance. All passages or corridors throughout the interior shall be made 20 inches in width for each 100 persons, but they shall have a minimum width of 4 feet.

SECTION 10. EMERGENCY EXITS

Emergency exits shall be provided of the same capacity as the entrances to each tier, opening into the alley at the rear or courts at side. There shall be at least two such exits for each tier on each side of the auditorium and shall be preferably at the top and bottom level of such tier. (See Fig. 2) No such exit shall be less than 4 feet wide. Doors shall open out in a recess in the wall same as for entrances and shall be provided with panic exit bolts arranged to open by pressure against them.

SECTION 11. PASSAGES OR COURTS

There shall be provided as in Section 2, courts on each side open to the sky of the following widths: 6 ft. wide up to 600 capacity; 8 ft. from 600 to 1,000; 9 ft. from 1,000 to 1,500; and 10 ft. wide over 1,500 total capacity of the theatre. These passages shall continue either to the street or thoroughfare in front or in back of the building and shall not be closed by any locked gate or doorway. If

it is necessary to pass through any section of the building, a corridor may be used having brick enclosing walls, and fireproof ceiling. The width of corridor shall be the same as that of passage and height shall not be less than 8 feet. The slope of the floor of such passages will not be greater than one foot in twelve feet, except an incline not less than ten ft. long may have a slope of two ft. in twelve ft. to reach the sidewalk or alley level. No steps will be permitted in the floor of such court.

SECTION 12. FIRE ESCAPES

The emergency exits of each tier shall be connected by exterior balconies and stairs leading from such exits to the passage level. (See Fig. 2) They shall be of steel construction built to carry a live load of 100 pounds per sq. ft. They shall be covered with a hood of sheet metal or enclosed when passing over an exit below. If the flight nearest the court level is counterbalanced, it shall be lowered during the performance. Outside balconies shall be as wide as the exit doorways fronting on them. The width of stairways shall be equal to ten inches for each 100 persons that they may serve, but no stairway shall be less than 3 feet 8 inches wide, and steps shall have a rise of not more than 8½ inches and a tread not less than 9½ inches. There shall be no openings in the theatre wall between the outside balconies and stairways and their covers except the required exits and no person of the audience shall be obliged to pass more than one exit doorway after reaching an outside balcony to get to the ground. (See Fig. 2) Each tier of dressing rooms shall be connected by an exterior balcony and stairway to the ground level. Such stair and balcony shall be of same construction as above, but may be three feet wide.

SECTION 13. STAIRS

All interior stairs shall be constructed of incombustible materials and designed to carry a live load of 100 lbs. per sq. ft. No winders shall be permitted. There shall be at least one or more separate and distinct stairways for each balcony and two for each gallery to the sidewalk level. The gallery stairs shall extend to the top level and shall have exits leading to it from each tier of that gallery. Such stairs shall rise from the entrance lobby or vestibule inside the building and the bottom run of such stair shall lead toward the street and the last riser shall not be further than 60 feet from such street. (See Fig. 1) No flight of stairs shall have less than three risers nor more than fifteen between landings. On stairs which return on themselves the landing be the full width of both flights with corners curved not less than two feet radius. Stairs with a right-angle turn shall have a landing the full width of the flight. Risers shall not be more than 7½ inches high and treads not less than 10 inches wide. The width of stairs shall be based on 20 inches per 100 persons served, but no stair shall be less than 4 ft. 6 in. wide. There shall be a handrail on both sides of stairs placed about 3 ft. above the steps and 3 in. from wall and on flights over 8 ft. wide there shall be a double handrail down the center of such flight with double newels 5 ft. high at ends. The stairs to the

top gallery shall be entirely enclosed but the stairway to the balcony may be open on one side. Stairways on the stage leading to dressing rooms shall be not less than 3 ft. wide. There shall be at least one stairway separated from the stage by a masonry wall leading from each tier of dressing rooms direct to the vestibuled entry of the stage. There shall be a stair to gridiron continuing to roof of stage. Such stair may be circular and may be thirty inches wide.

SECTION 14. STAGE WALLS AND CURTAIN

There shall be a solid masonry wall of the same thickness as the main wall of the building separating the stage portion from the auditorium. This wall shall extend at least 4 feet above the stage roof or the auditorium roof if the latter is higher. The proscenium opening shall be covered with a curtain of asbestos, or steel and asbestos, or other fireproof construction. It shall lap at least one foot on each side of the opening and two feet at the top and shall slide at least 6 inches in metal grooves fastened to the brick wall. The curtain shall be in constant use as the regular curtain and act drop. There shall be but four other openings in the proscenium wall, two on the stage level and two below. These openings shall be no greater than 21 sq. ft. each and shall be protected with automatic fire doors. Other openings in the stage walls shall be protected with fire doors or wire glass windows, in metal frames. No iron guards shall be placed on these windows. There shall be least two exits not less than 4 ft. wide on the stage level one on either side of the stage leading to the outside. These must be vestibuled. (See Fig. 1) Every building used for the presentation of motion pictures only as specified in Section 2, shall not have a stage or proscenium opening. The screen for the picture shall be placed not further than 6 inches from the rear wall of the theatre and a platform not exceeding 80 sq. ft. may be placed in front of it. No rooms of any kind shall be placed between the auditorium and the rear wall of the building.

SECTION 15. DRESSING ROOMS

Dressing rooms shall not be placed on or under the stage or in or under the auditorium. The dressing room section shall be separated from the stage or auditorium by a masonry wall at least 8 inches thick and all openings to the stage shall be protected with self-closing fire doors. All partitions, doors and fittings of every description shall be of incombustible material. All dressing rooms shall be ventilated by fire windows to street or court not less than 24 sq. ft. in area.

SECTION 16. STAGE VENTILATORS.

Over the stage there shall be one or more ventilators built of incombustible material having a free opening and sectional area of at least 10 per cent of the area of the stage. This ventilator shall have either a damper or sliding or hinged sash arranged to open in case of fire. The construction of the damper and the operating mechanism shall be massive and the damper or sash shall open by force of gravity sufficient to effectively overcome the effects of

neglect, rust, dirt, frost, snow or expansion by heat or warping of framework. If glass is used it shall be protected against falling on the stage by a wire screen so arranged that if clogged the effective area will not be reduced or the operating mechanism interfered with. Automatic fusible links shall be used to open the damper or sash in case of fire in addition to manual control provided by a cord run to point on the stage designated by the superintendent.

SECTION 17. PROTECTION OF STAGE

There shall be a standard wet pipe system of automatic sprinklers controlling the entire theatre except the auditorium, lobbies and foyers. Sprinkler openings shall be placed around the proscenium opening in back of the curtain so as to form a water curtain when they are opened. There shall be a standard system of standpipes with two 2½-inch diameter outlets at each level of the auditorium and at stage level. Also one outlet at each dressing-room level and gridiron. Each outlet shall be provided with a sufficient length of 1½-inch hose so as to reach all parts of the tier which it controls. There shall be a full equipment of axes, hooks, chemical fire extinguishers and water barrels placed in various parts of the stage to combat the spread of fire. All stage scenery, curtains and decorations made of combustible material shall be painted with a non-combustible material.

SECTION 18. LIGHTING

Electric light only shall be permitted on the auditorium and stage portions except that gas light may be used to indicate exits. If exits are indicated by electric light, this service shall have a separate control and be connected ahead of the main service.

SECTION 19. BOILER ROOMS AND CARPENTER SHOP.

Boiler rooms, carpenter or scenery painting shops shall be separated from the auditorium and stage by a fireproof floor or masonry wall or both, and have automatic fire doors in the connecting openings.

SECTION 20. STAGE FLOORS

The gridiron shall have a metal lattice floor designed to carry a live load of 75 pounds per sq. ft. Fly galleries shall be of fireproof construction designed to carry 90 pounds per sq. ft. All of the stage except the part usually covered by floor traps of no greater width than the proscenium opening and depth from proscenium to rear wall shall be of fireproof construction. The non-fireproof part shall be of heavy timber or steel beam construction. All shall be designed to carry at least 100 pounds live load per sq. ft.

SECTION 21. PROJECTION ROOM

Every projection room shall be large enough to permit the projectionist to walk freely on three sides of the machine. Walls shall be of concrete or tile at least 4 inches thick and all doors leading from the room to be self-closing fire doors. Openings for picture projection shall be protected with heavy sheet metal drops arranged to slide in grooves. They shall be controlled by cords arranged in

such a manner that they will automatically close at the outbreak of fire. All shelving and fittings shall be of incombustible material and all films not in use shall be kept in tight-covered metal cans. There shall be a ventilator at least 12 inches in diameter leading from the top of the room to the outside air.

Conclusion

If these requirements are carefully followed out in the planning of a theatre, it would appear that the building should be safe. The fallacy of this was proved by the Iroquois disaster in Chicago. This theatre was the last word in fireproof construction and careful planning. In his paper on "The Safeguard of Life in Theatres," by President John R. Freeman, presented to the American Society of Mechanical Engineers, he states: "At the time of the fire in the Iroquois, that fire pails and soda water fire extinguishers were absent and that ventilating skylights over the stage were blocked so that they could not slide open, and that exits were poorly marked, and that there was a delay in providing the fire hose on the stage."

Therefore, combined with these standard requirements, must be the careful attention by the management as well as frequent and efficient inspection by the authorities. On account of the many places on a theatre stage and adjoining property rooms where rubbish and junk may accumulate without being noticed because of the lack of light, it is very necessary that the management exercise constant vigilance to prevent the danger of fire.

In defense of some of the old non-fireproof theatres one might say that as far as safety to the audience is concerned, it is far better to have very clear and intelligent planning, such that the patrons can easily find their way out, than absolute fireproof construction, as the great loss of life has usually happened within five minutes of the first flame. So, if a theatre can be emptied in two to three minutes, the audience will hardly suffer even if the building is of ordinary construction. In the Iroquois, the underwriter loss was practically nothing while the human toll was enormous. Mr. E. O. Sachs, the London architect, in his account of some one thousand theatre fires, states that the requirements of safety to the audience should be placed in the following order: "Good planning first, efficient and constant watching by the management, careful and frequent inspection, and fire-resisting construction last."

At present untold sums are being spent for theatres. Each new building being larger or more lavishly decorated than any other. Picture presentation has developed into one of the highest arts, requiring wonderful stage settings, orchestration and lighting effects. The management is constantly on the alert to invent something new to provide amusement and enjoyment for their patrons.

The Interior Illumination of the Motion-Picture Theatre

By L. A. Jones

The desirability of providing sufficient illumination for the convenience and comfort of the audience, if this can be accomplished without perceptible loss of quality in the projected picture, is obvious. It is scarcely necessary to enumerate the many serious objections to the use of very dimly lighted rooms in which motion pictures are being exhibited to large audiences. The difficulty encountered by persons entering from the relatively brightly lighted exterior regions in finding their way to unoccupied seats is considerable. The undue strain thrown upon the accommodation processes of the retina resulting from a sudden transition from a brightly lighted exterior to a dark interior, or vice versa, is very objectionable and to be avoided if possible. More serious than these, however, is the excessive visual fatigue and eye-strain resulting from a prolonged observation of a brightly illuminated area (such as the screen on which the picture is being projected) occupying but a small portion of the field of view and surrounded by very dark areas, this condition being ideal for the production of glare effects due to excessive contrasts. It is evident for the satisfactory exhibition of motion pictures that the general illumination in the theater must be subdued in order that the projected picture shall be of good quality as regards its apparent brightness and contrast, and that in raising the value of the general room illumination there is a limit beyond which it is impossible to go without seriously affecting these characteristics of the picture. However, it has been found by proper distribution of the light that the general room illumination can be raised to a value sufficient to eliminate all of the objections to a dimly lighted theatre and at the same time produce no perceptible injurious effect upon the quality of the projected picture.

The object, therefore, with which this work was undertaken was the determination of the maximum value of general illumination allowable in a theatre when motion pictures are being exhibited, this allowable maximum being defined as the highest value of general illumination which will not cause any appreciable diminution of apparent contrast in the projected picture. From a consideration of the fundamental data available relative to the various retinal sensibilities, it is possible to draw certain general conclusions as to the most desirable conditions of illumination for this purpose. The data available, however, are not sufficiently complete to permit the computation of the desired values, and hence it was necessary to resort to experiment and actually to measure in an experimental installation the illumination which was found to be permissible without causing loss of quality in the projected picture.

Before proceeding with an account of the experimental work, it may be well to consider briefly the general theory of the subject, and the fundamental characteristics of the eye which are important in problems of this nature. First of all, it should be borne

in mind that the sensation produced when light falls upon the retina depends upon several factors, such as the intensity of the light, the length of time during which the stimulation continues, wave-length of the radiation, the size and shape of the retinal area stimulated, and the physiological conditions of the retina due to previous action of light upon it. It is sufficient for the present purpose to consider only the reactions of the retina to the intensity factors of the stimulus and neglect those which are functions of its quality.

Of first importance among the factors requiring consideration is the sensibility of the retina to brightness. There are three types of brightness sensibility: (1) threshold sensibility, which is measured by the least brightness perceptible; (2) contrast sensibility, which is measured by the least brightness difference perceptible; and (3) glare sensibility, which is measured by the brightness just sufficient to produce discomfort when observed.

Now the sensibility of the eye to brightness, contrast, and glare depends upon the condition of the retina at the particular time the determination is made, and that condition is in turn dependent upon the previous stimulation. Hence, it is necessary to specify the condition of the retina at the time the measurement of sensibility is made. This is done by specifying the brightness to which the eye is adapted, and is termed the "adaptation level" of the retina. For instance, when an observer looks for some time (10 to 30 minutes) at a uniformly illuminated surface so large as practically to fill the field of vision, a condition of equilibrium in the retinal process is reached, and the observer's eye is said to be adapted to the brightness of the field, and his "adaptation level" is specified by stating the brightness of the illuminated surface, which is sometimes termed the "sensitizing field." It is found that the sensibility of the retina varies over very wide limits depending upon the adaptation level; in fact due to this variable sensibility it is able to operate over a range of brightness from 1 to 100,000,000 (approximately). A complete expression of sensibility therefore requires measurement over the entire adaptation range, and the results are most conveniently expressed in graphic form as curves plotted with values of the various types of sensibility (threshold, contrast, and glare) as ordinates and the adaptation level as abscissae. These three sensibility curves are given in Fig. 1.*

Since the variation in value of adaptation level (field brightness) is enormous, it is necessary in plotting the curves to use the logarithms of these values. The ordinates are expressed in units appropriate to the various types of sensibility. For any specified adaptation level, it is now possible to read from the curves the brightness which is just uncomfortable (producing glare), the least perceptible difference in brightness (contrast), and the least perceptible brightness (threshold). Applying this to the case of an

* Nutting, P. G., The Fundamental Principles of Good Lighting, J. Frank. Inst., 183: 1917, p. 287.
Blanchard, Julian, The Brightness Sensibility of the Retina, Phys. Rev. XI, No. 2, 1918, p. 81.

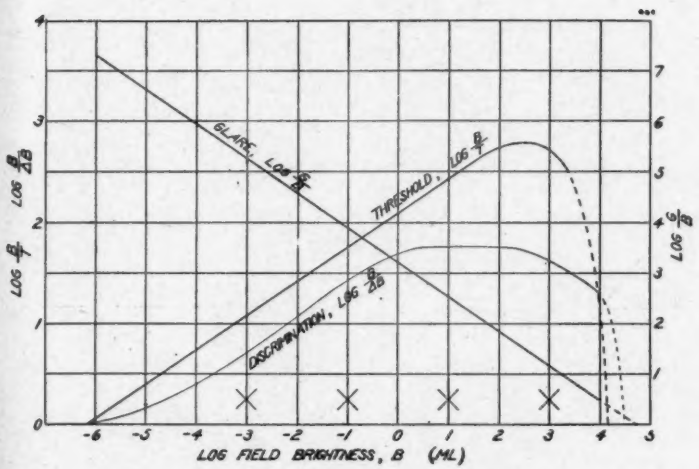


Fig. 1.

observer in a motion-picture theater, we are able if his adaptation level is known to find to what extent any area may be illuminated without producing glare, to compute the amount of general illumination which may be tolerated on the screen without producing a perceptible degradation of contrast, or to specify the maximum of brightness difference in the field of vision if undue eye fatigue is to be avoided.

In order to make such useful application of the fundamental data contained in the sensibility curves, it is, however, necessary to know the adaptation level of the observer under the particular conditions considered. Unfortunately the data necessary for this are not at present available. It will be recalled that the "adaptation level" is defined as specified by the brightness of a uniformly illuminated field filling the entire field of vision, and the retinal sensibilities were determined under such conditions. Now it is probable that the brightness of the foveal image is the most important factor in fixing the adaptation level of the retina, but undoubtedly the brightness of the images outside of the fovea have some influence. In the case of a person watching a motion picture, the picture itself occupies but a relatively small portion of the visual field, and in case the surrounding areas are very low in brightness his adaptation level will probably be somewhat lower than indicated by the average picture brightness. The effective application of the sensibility data, therefore, depends upon a reliable determination of the adaptation level under practical working conditions in the motion-picture theater. An instrument is at present being developed with which the adaptation level of the retina when stimulated by non-uniform fields may be measured. It is hoped when such measurements are available that the application of the sensibility data will

lend additional support to the conclusions reached in the experimental work to be described in the following pages.

In order to make an actual determination of the maximum general illumination permissible, an experimental lighting system was installed in the Projection Room in the Research Laboratory. In designing this system an attempt was made to obtain the maximum average illumination on the table plane (horizontal surface 30 inches above the floor) with a minimum of illumination on the projection screen, and further to distribute the light so that no area either of wall, ceiling, or lighting fixture should be sufficiently bright to

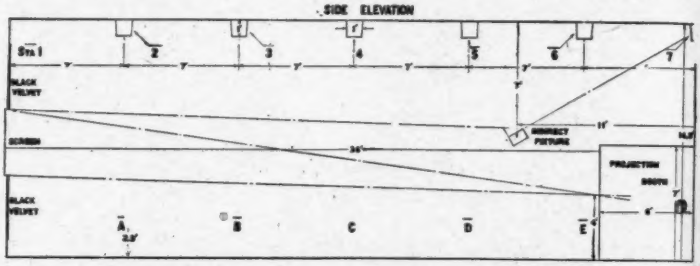


Fig. 2.

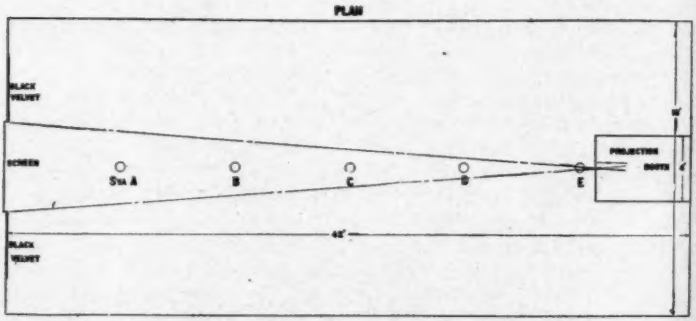


Fig. 3.

cause glare or appreciable increase in the adaptation level of the observer.

In Fig. 2 is shown a side elevation of the room with the locations of the various elements of interest in this problem and the dimensions of importance. In Fig. 3 is given a plan view and in Fig. 4 an end elevation showing screen with its surrounding frame of black velvet. The ceiling of this room is painted white, while the walls are a medium tone of buff. The projection screen is of the metallic type (Gaumont), having a high reflecting power for points on and near the axis, but falling off rapidly for angles of greater than 15° from the axis.

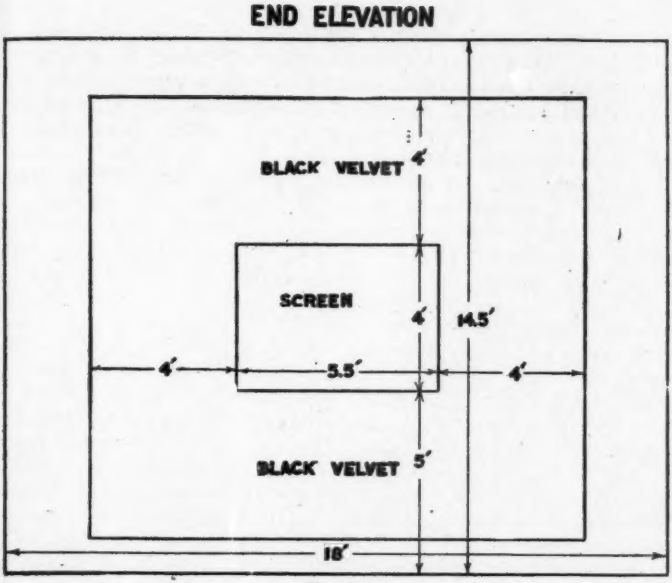


Fig. 4.

The lighting fixture was constructed by mounting six 10 x 12 darkroom ceiling lamps on a light wooden frame work. In order that the position of this fixture could be adjusted to give various distribution of the light, it was suspended as shown in Fig. 5.

The vertical members *AA* carry the horizontal member *B*, which is a cylindrical metal rod about 21 feet long. One of these fixtures is mounted near each side of the room, and parallel to each other. Upon these horizontal ways operate the sliding carriages *C*. Over small pulleys attached to this carriage, the sash cords *FF* operate and suspend the lighting fixture as shown. By

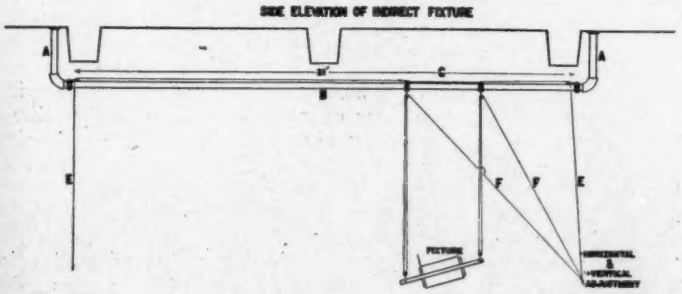


Fig. 5.

means of these adjustments, it is possible to adjust the position of the lighting fixtures to any desired distance from the ceiling, to vary its distance from the projection screen by a considerable amount and further to vary the inclination at which the fixture hangs thus controlling to a great extent the distribution of the light from the fixture.

Complete diffusion of the light from the incandescent lamps mounted in the fixture was obtained by inserting a sheet of 10 x 12 opal glass in the position provided for holding the safelight. This material is of such nature that the light transmitted is very completely diffused. In the projection booth is situated a projection machine of the ordinary type. An arc current of 25 amperes was used throughout the tests recorded in this report. With this current the screen brightness as measured with the machine running but without a picture in position was found to be approximately 20 milli-lamberts. This measurement was made from a point very near to the axis of projection and due to the character of the screen was much higher than the brightness measurement made from points a few degrees from the axis. From measurements made previously in several of the motion-picture theatres in Rochester, an average value of screen brightness under similar conditions was found to be approximately 15 milli-lamberts. The screen brightness used in these experiments therefore is somewhat higher than is ordinarily met with in practice.

The lighting fixtures having been installed, the procedure followed was to determine by trial and error the maximum amount of light which it was possible to use without causing an appreciable loss of quality in the picture. After several preliminary trials it was decided that the best result was obtained by placing 60-watt lamps in the four central elements of the fixture and 40-watt lamps in each of the end boxes, the entire 10 x 12 surface of the diffusing glass being uncovered and used as effective source area. The position of the fixture which was found to give a very satisfactory distribution of the light was as indicated in Fig. II. This position was approximately five feet from the ceiling and eleven feet from the rear wall of the room, and with the fixture inclined forward so as to give an evenly graduated distribution of the light on the ceiling. It was found necessary in order to prevent excessive illumination of the screen by the light from the fixture to place a cardboard screen along the front of the frame carrying the safelight fixtures. This was of such dimensions that no direct light from the opal glass was permitted to fall upon the projection screen, and served also to reflect some of the light backward, so that the ceiling brightness at the rear of the room was brought up to a value more nearly equal to that of the brightness of the ceiling directly above the fixture.

This arrangement having been arrived at and considered satisfactory, several experienced observers were asked to express opinions as to whether or not the quality of the projected picture was seriously affected by the presence of this general room illumination.

By observing the screen with the eyes so shielded that nothing but the picture could be seen, the ceiling lights were alternately turned off and on, and the effect upon the quality of the picture observed. While it is possible to detect a slight veiling of the deeper shadows when the room illumination is being used, the effect is so slight as to be inappreciable in causing a degradation of the contrast of the picture.

Undoubtedly the veiling illumination falling upon the screen from the general illumination in the room is sufficient to cause an easily measurable decrease in actual contrast of the picture. Actual observation, however, shows that this decrease in contrast is not apparent to the observer. The explanation of why this decrease in contrast produces such a small apparent effect is of considerable interest, and is, in fact, of fundamental importance. The explanation lies in the fact that the contrast sensibility of the retina increases as the adaptation level rises. The presence of the general room illumination is responsible for a rise in the adaptation level of the observer, and the corresponding increase in contrast sensibility permits the perception of smaller brightness differences. If in the projected picture a constant contrast has been maintained, this increase in contrast sensibility would tend to make the picture look more contrasty, but since the presence of veiling glare tends to decrease the actual contrast, the two effects work in opposite directions and tend to compensate each other, the result being no perceptible change in apparent contrast.

On the whole this arrangement was considered very satisfactory by all those observing. One point of interest noted was that much less visual discomfort resulted when the screen brightness was suddenly changed by the appearance of the title region of the film, and further that a slight residual flicker due to lack of precise shutter adjustment was less noticeable. In fact much less general eye fatigue resulted when the room lights were on than when they were turned off.

In order then that a permanent record of the quantity and distribution of illumination used might be obtained, a series of brightness and illumination measurements were made. For this purpose the Macbeth illuminometer properly calibrated was used. The points at which measurements were made are indicated in Fig. 2. The stations *A, B, C, D,* and *E,* represent points on the table plane, that is, 30 inches from the floor, while the stations, 1, 2, 3, 4, 5, 6, and 7 are situated at various points on the ceiling as indicated by the arrows and represent the points of maximum brightness as seen by an observer situated at a point near station *D*. All values of brightness are expressed in milli-lamberts (m. l.) and those of illumination in foot candles (f. c.). In order that a complete analysis of the distribution of the light might be made, sets of measurements were made under four conditions of illuminations as follows:

I. Ceiling lights on. Arc not operating.
II. Ceiling lights on and arc operating. No picture in the machine.

III. Arc operating, no picture, no ceiling lights.
IV. Ceiling lights and arc with picture.

The measurements obtained under I. indicate the intensity and distribution of the light from the installed fixture. The data in III. represent the intensities and distribution of the light reflected from the screen when the arc is operating but with no picture in the machine. The data in IV. are of greatest interest, as they represent the distribution and intensity of the illumination under actual operating conditions, the sources of light being both the installed fixture and the light reflected from the projection screen. The data in II. were recorded as being of interest in indicating the difference between the illumination with and without a picture in the projecting machine.

The measurements having been completed with this arrangement of the lighting fixture, it was decided to make a second adjustment and to repeat the measurements with slightly changed conditions. The distance between the fixture and ceiling was increased to 7 feet, and the inclination changed somewhat so that while the projection screen was protected from direct light a higher ceiling brightness near the front of the room was obtained. The photometric measurements were then repeated from the same set of groupings as employed previously. The data on the two arrangements of the lighting system are recorded in Table I. A detailed consideration of this table will not be given at this time.

In order to present this data in more graphic form, the values of brightness and illumination are written in at the proper position on prints showing the side elevation of the room, and a brief consideration of these will be taken up. The conditions obtained with the second arrangement of the fixture were somewhat more satisfactory than the former, hence our attention will be confined entirely to the values obtained with this more favorable arrangement.

In Fig. 6 the data obtained with the ceiling lights on but without the projection arc are shown. It will be noted that the maximum ceiling brightness is obtained slightly in front of the fixture, the maximum being 1.9 ml. This brightness decreases gradually toward the front of the projection room. The illumination on the table plane due to this source is indicated by the figures at stations *A*, *B*, *C*, *D*, and *E*.

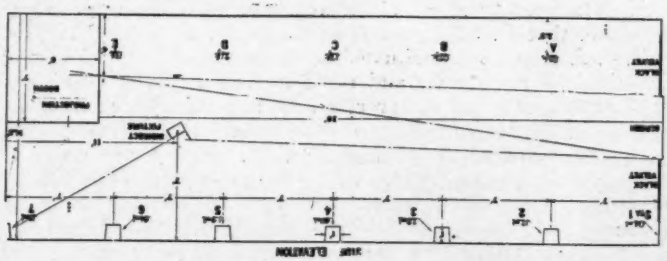


Fig. 6.

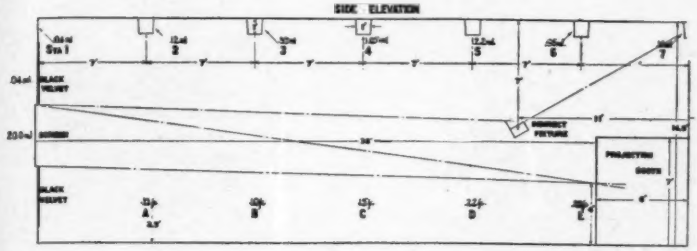


Fig. 7.

In Fig. 7 brightness and illumination values at corresponding stations are shown, the condition being that ceiling lights were on and the projection machine operating but without a picture in the machine. A comparison of these values with those in the previous figure shows the magnitude of the illumination resulting from the light reflected from the projection screen, its influence being most marked near the front of the room. This is more clearly shown by Fig. 8, in which the measurements of illumination due to the light reflected from the projection screen alone are indicated.

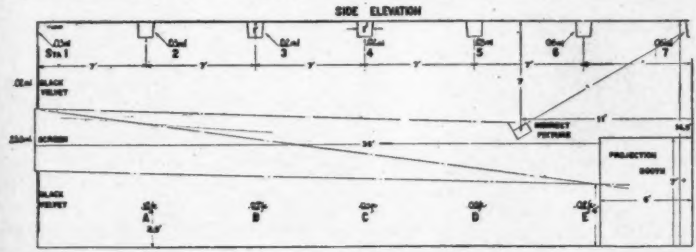


Fig. 8.

The data of greatest interest, however, are shown in Fig. 9, these being the values obtained by taking measurements under actual operating conditions, that is, with the projection machine operated in the usual way with a picture of normal density and the lights providing the general room illumination turned on. It will be noted that the ceiling brightness is relatively high near the rear of the room, its maximum being 1.8 ml. This brightness decreases to a value of .04 ml. directly above the projection screen. The illumination on the table plane is also high at the rear of the room at a maximum value of .19 f. c. and a minimum value of .06 near the front.

This arrangement of the room illumination was found to be entirely satisfactory from the standpoint of the picture quality. No appreciable diminution in the apparent contrast or brightness

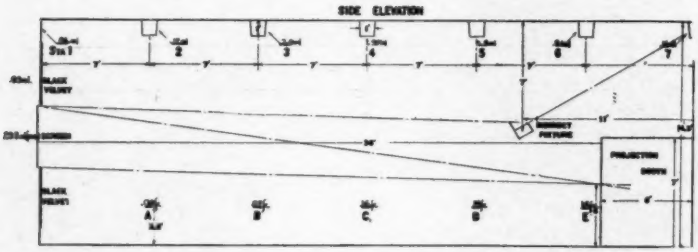


Fig. 9.

of the picture was perceptible. With this illumination it is quite possible after becoming accommodated to the existing brightness level to read with comfort ordinary newspaper print, and furthermore the length of time required for accommodation is very short. For instance, an observer entering the room with eyes adapted to full exterior daylight levels can see immediately every detail of furniture in the room and a period of not more than one or two minutes is necessary for adaptation sufficient to read with ease ordinary printed material.

The general conclusions to be drawn from these experiments are that a relatively large amount of general illumination may exist in motion-picture theaters without appreciably affecting the quality of the projected picture, provided that this illumination is properly distributed.

In Fig. 10 is shown a possible arrangement of the lighting system which would give a highly satisfactory theater illumination. This plan is presented as illustrative of one way of handling the problem and undoubtedly many others may be worked out.

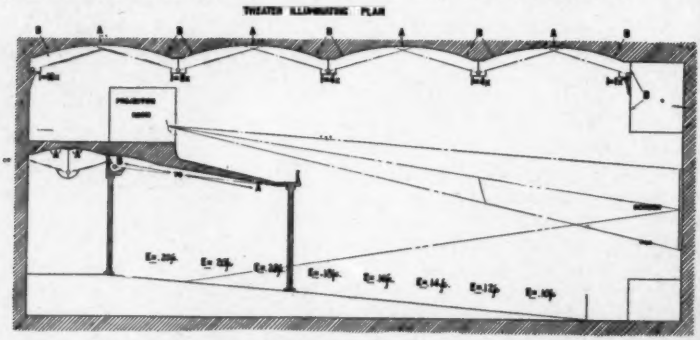


Fig. 10.

The ceiling which consists of four arches or concavely curved surfaces is illuminated by lamps inclosed in the fixtures, which are designed to appear as integral parts of the beam structure, as

indicated. The intensity of the various lights is distributed roughly as indicated by the numbers i = ix, i = 4x, etc. This would result in a relatively high ceiling brightness at the rear of the theater and a relatively low value at the front. Since the lamps themselves must be placed comparatively close to the ceiling, it would be necessary in order to obtain an approximately uniformly graded ceiling brightness, to arrange the decorative scheme applied to the ceiling so that the regions marked *B* should have a relatively low reflecting power, while those marked *A*, on the other hand, would have a very high reflective power. The details of some such decorative systems have been worked out, but they will not be considered at this time. The lighting of the ceiling underneath the gallery is obtained from lamps at *B* and here again the ceiling reflecting power should vary from a low value at *B* to a high value at *A*.

From the result of the experiments in the projection room, it has been concluded that the illumination on the table plane at various points in the theater should be approximately as indicated by the values of *E*, and the number and size of the light units used should be so adjusted as to give the indicated values. While an approximate computation could be made indicating the number and size of units necessary, it would be quite impossible without detailed information of the dimensions of the room, the reflecting power of various surfaces, and the exact positions of the lamps to make a definite estimate as to the total quantity of light flux necessary.

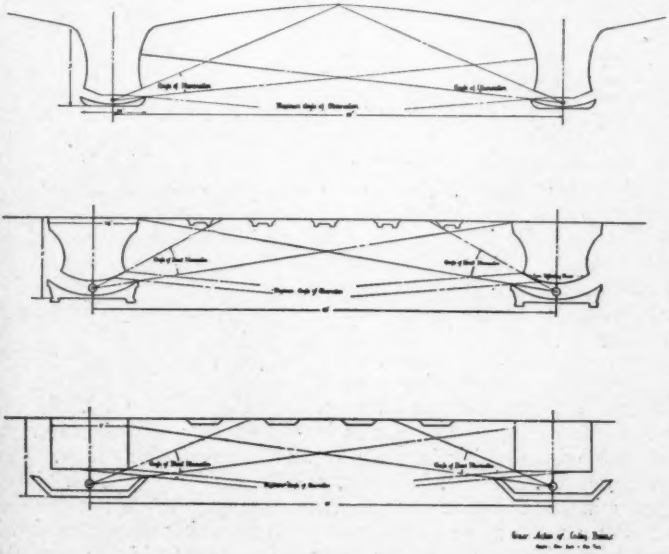


Fig. 11.

In Fig. 11 are shown three cross-sectional diagrams illustrating the possibilities in beam design which would result in the proper distribution of the light flux over the ceiling. These designs, of course, are only given as suggestions of what might be done in arranging an indirect system of illumination conforming with the conditions outlined in this report. The beam structure adopted in any particular case will be influenced to a great extent by the architectural style of the theater and the diagram given serves only to suggest a method of concealing the lamp within the beam structure and at the same time obtaining the proper illumination of the ceiling.

It should be mentioned also that the illumination in the lobby and in the various vestibules and extreme rear of the theater should be so arranged that a person entering the theater passes gradually from the illumination of the exterior to that of the body of the theater. That is, the transition from exterior brightness level to the interior brightness level should be made in a series of gradual steps rather than in a single abrupt step.

Returning again to a consideration of the brightness of the frame surrounding a picture, it was found by experiment that raising the brightness of the frame to a value of approximately .02 m. l. gave a much more pleasing effect than when the black velvet frame was used in which case the brightness was so low as to be beyond the limit of measurement with the instrument available. The contrast between the frame and the highlight of the projected picture, which is estimated to have been about 1 to 10,000 in case of the black velvet frame was found to give rise to a certain feeling of visual fatigue and discomfort. By covering the velvet with a draping of white mill net the reflecting power was increased to such an extent that the contrast between the frame and picture was considerably reduced. It will be noted that the average screen brightness without any picture in the screen is found to be 20 m. l. The average screen brightness with a normal film in position is probably of the order of 2 m. l. while the maximum may be taken to be somewhere in the neighborhood of 10 m. l. With a frame brightness of from .02 to .03 as indicated by the data, the maximum contrast between picture and frame is reduced to less than 1 to 1,000, while the average contrast is approximately 1 to 100. Now the sensitometric data on glare indicate that with the eye adapted to ordinary daylight levels a contrast of over 1 to 100 results in glare or undue fatigue. However, with the eye adapted to lower levels, the allowable contrast increases to a considerable extent and if (See Fig. 1) we assume an adaptation level of 1 m. l. the data indicate that contrast as great as 1 to 1,000 may occur in the visual field without resulting in glare or undue visual discomfort. Contrast greater than this, however, should not be permitted. These results indicate that in general a black frame should not be used, but that a much more pleasing and less fatiguing arrangement will be obtained by the use of the frame of somewhat higher reflecting power.

The general conclusions are, therefore, as follows:

By proper distribution of the light, the general illumination of the interior of a motion picture theater may be raised to a considerable extent above the values in common use without causing any appreciable loss of quality in the projected picture. The illumination on the table plane in fact may be raised to the point where ordinary news print can be read with ease by an eye adapted to the existing brightness level.

While it is impossible to outline specific instructions for particular cases without detailed knowledge of such factors as dimensions and architectural details of the room, the reflecting power of the various ceiling and wall surfaces, and the position of the light fixtures, the following general principles may be outlined.

(1) The illumination on the table plane should vary from .10 foot candles at the front of the theater to .20 foot candles at the rear.

(2) No area (outside of the projected picture) visible from any seat in the theater should have a brightness of more than 2.5 to 3.0 m. l.

(3) The attainment of (1) without exceeding the values mentioned in (2) requires the use of very extended effective sources such as illuminated ceiling and walls and is best accomplished by the use of an indirect system of lighting.

(4) All light sources and fixtures such as diffusing globes and translucent glass ware having a surface brightness of more than 2.5 to 3.0 apparent milli-lamberts should be entirely concealed from view.

(5) It should be noted that a sheet of white paper illuminated by a 25-watt lamp at a distance of 12 inches has an approximate brightness of 20 milli-lamberts. A sheet of music, therefore, illuminated in this way if visible becomes a glare spot and may cause great discomfort to the audience. Arrangements should therefore be made which, while providing adequate illumination for the musicians in the orchestra, will prevent the illuminated music sheets from being visible to the audience.

(6) The contrast between the highest light of the picture and the surrounding frame should be less than 1 to 1,000, preferably less than 1 to 500. Black frames should, therefore be avoided, one of a neutral gray being much preferable.

(7) Lighting of lobby, vestibules, etc., should be so arranged that the transition from the brightness level of the exterior to that of the interior, or vice versa, is accomplished by a series of small differences rather than by a single large one. Such arrangement will to a great extent eliminate the visual shock which accompanies a sudden change in the intensity of the visual stimulus.

(8) The use of a projection screen set well back on the stage and thus shielded to a great extent from the light reflected from

ceiling and walls would probably permit the use of even greater room illumination than was used in these experiments.

TABLE

		Ceiling Brightness							Illumination on Table Plane, Screen and Frame					
		1	2	3	4	5	6	7	A	B	C	D	E	S	F
I.	A	.02	.05	.14	.84	2.7	1.2	1.4	.02	.05	.10	.15	.19	.02	.01
II.	A	.03	.07	.14	.84	2.6	1.3	.18	.15	.09	.15	.15	.17	20.00	.03
III.	A	.03	.03	.02	.02	.03	.06	.05	.10	.05	.03	.03	.03	20.00	.02
IV.	A	.02	.04	.14	.84	2.3	1.3	.15	.04	.04	.13	.15	.19	10.00	.02
I.	B	.04	.12	.28	.95	1.9	.84	.15	.03	.07	.17	.21	.17	.04	.02
II.	B	.04	.12	.37	1.05	2.2	.95	.16	.13	.10	.15	.22	.20	20.00	.04
III.	B	.03	.03	.02	.02	.03	.06	.05	.10	.05	.03	.02	.02	20.00	.02
IV.	B	.04	.12	.29	.95	1.8	.84	.16	.06	.07	.16	.19	.16	10.00	.03

I. Ceiling Lights On, Arc Not Operating.
II. Ceiling Lights On, Arc Operating, No Picture.
III. Ceiling Lights Off, Arc Operating, No Picture.
IV. Ceiling Lights On, Arc. Picture on Screen.

Continuous Motion-Picture Machines

By C. Francis Jenkins

America's supremacy comes about by reason of her social-economic engines. She has given the world more mechanisms to do what had theretofore been done by hand, than all other countries combined; and because we are great folks to love our neighbors, some of our most brilliant efforts have been to facilitate intercourse, for intercourse means friendliness. So we have given the world instruments to promote sociability, the telegraph, the telephone, the typewriter, the talking machine, the typesetting machine, and now we add the motion-picture machine to hasten our means of knowing each other.

The motion picture, as applied to the picture theatre, is already the fifth largest industry. When to this is added the much wider field outside the theatre, it is not beyond the range of probability that motion pictures will become the largest single industry in the world. And this probability is strengthened by the fact that the motion picture film is standard the world over. Not only is it the only world standard, but it is unique in other ways. For example:

It is a curious anomaly that in the motion-picture projecting machine business, the usual rule of supply and demand does not hold good. One may buy anything else, a watch, an automobile, a house, paying as much or as little as one chooses, getting increased value with increased cost, but for a motion-picture projector one pays about the same price for all makes.

There is not today a picture equipment comparable with the magnificence of a great many of the theatres already built and many more projected. No matter how much the builder of a fine theatre may desire it, he cannot get a correspondingly fine picture equipment; it doesn't exist; the only machine available is the same cheap-priced, old style machine used in the little five-cent movie house.

The theatre owner may pay as much or as little as he likes for music and other accessories, but when it comes to the picture machine, that which produces the thing he sells to the public, he is limited to a very small choice, a choice in name mostly, for the three or four machines available all sell for about the same price.

The reason for this is that the old-style longitudinal projector has inherent limitations, and has been developed just about as far as it is possible to go. For added cost one gets more cast iron only, the quality of the picture on the screen is not noticeably different.

This inherent limitation is the intermittently moved film, for the same reason that reciprocation limits the use of the steam engine. One does not think of fractional steam motors, for example, though we all find daily use for small continuous rotation electric motors.

Of course, such reasoning applied to motion-picture machines leads us directly to a study of the continuous motion film projector, a subject from which motion-picture engineers shy, as scientists used to shy at the subject of flying machines. But that way is the road out of our projection difficulties, and any investigation and

experimentation along that line is worth while and this is my warrant for presenting the following description of a new contribution to the subject.

Everyone readily admits the advantages to be gained by the employment of continuous instead of intermittently moved film. Striking advantages are immediately suggested: (1) Longer life for the film, consequently larger revenue from each print; (2) 100% increase in lighting efficiency, i. e., the same screen lighting with 50% of the present light source intensity; (3) a noiseless and much less complicated projecting machine; and, (4) almost unlimited speed (not for the projectionist, many of them need a speed-limiting brake), but continuous motion in a camera permits such speeds as open up possibilities for scientific research not available in any other way. Sharp, clear, discrete pictures at a rate of 50,000 per minute are possible with fast lenses and super-sensitive film now available if suitable film-handling mechanism could be found. Such pictures subsequently projected at normal speed, say 1,000 pictures per minute, are destined to disclose many things impossible of discovery without such apparatus.

Many attempts to attain this ideal machine have appeared from time to time and hundreds of patents have been granted thereon, but most of them propose continuous motion of the film while employing intermittent or reciprocating mechanism. This is not, and cannot be the solution of the problem, for the parts moving intermittently are a greater handicap than the film, because they are many times heavier than that part of the film having step-by-step motion, and we are no better off than before, being still limited to the restricted speeds inherent in intermittent mechanisms.

In my initial work of thirty years ago, I employed both continuous and intermittent motion mechanisms. The intermittent first got general public acceptance because it was the easiest and cheapest made, and this and all subsequent mechanisms the world over are basicly alike in principle and curiously alike in construction, for example, all are built left-handed.

Of machines having continuous motion of both film and mechanism, the only example of my own ever attaining any considerable degree of speed and picture perfection employed continuously moving film and a plurality of lenses following each other in sequence and single line procession across a stationary shutter opening, which, as you will observe, is exactly the reverse of the intermittent mechanism in which the shutter is in continuous rotation while the lens and film are stationary at the instant of exposure.

But the cost of this large number of lenses and the difficulty of getting them matched gave the intermittent projector the long start it has maintained to this day, though an examination of the old apparatus in its various forms on exhibit in the U. S. National Museum where it was put some twenty-six years ago is interesting from other than an historical point of view. The number of different and unprofitable ways a basketball of expensive lenses can be put

together again suggests the old proverb that "a fool and his money are soon parted."

Therefore, the contribution to the art which I shall describe herein is the result of experimentation with the object of producing a less expensive machine, while keeping in mind all the time, the absolute necessity of employing (1) standard film; (2) stock lenses and light sources; and (3) continuous motion of every part of both

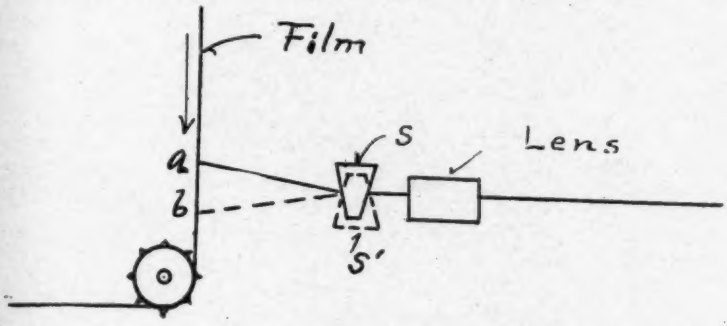


Fig. 1.

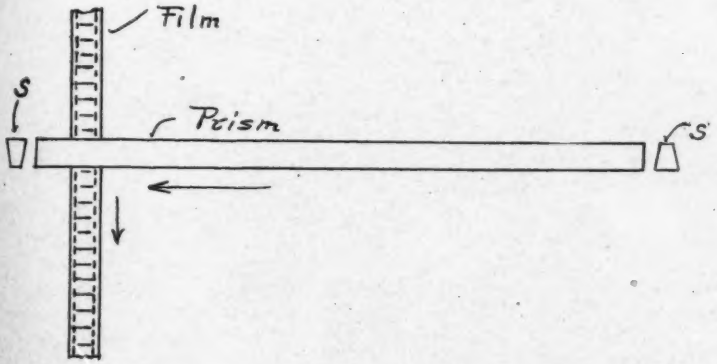


Fig. 2.

film and mechanism. As to the success attained I shall leave you to judge for yourself from your own observation of machine and screen picture.

This machine, considered first as a camera, is built on the principle that if a ray of light coming from a distant point could be bent just after passing through the lens so that it would impinge on the film at an initial position, that is, at the top of the aperture, and should then be caused to travel down one frame in exact syn-

chronism with the movement of the film, our problem would be solved.

This bending of the ray of light just after passing through the lens can be accomplished by interposing a prism, say of 5 degree angle, with its base up (S, Fig. 1) which will project the ray to

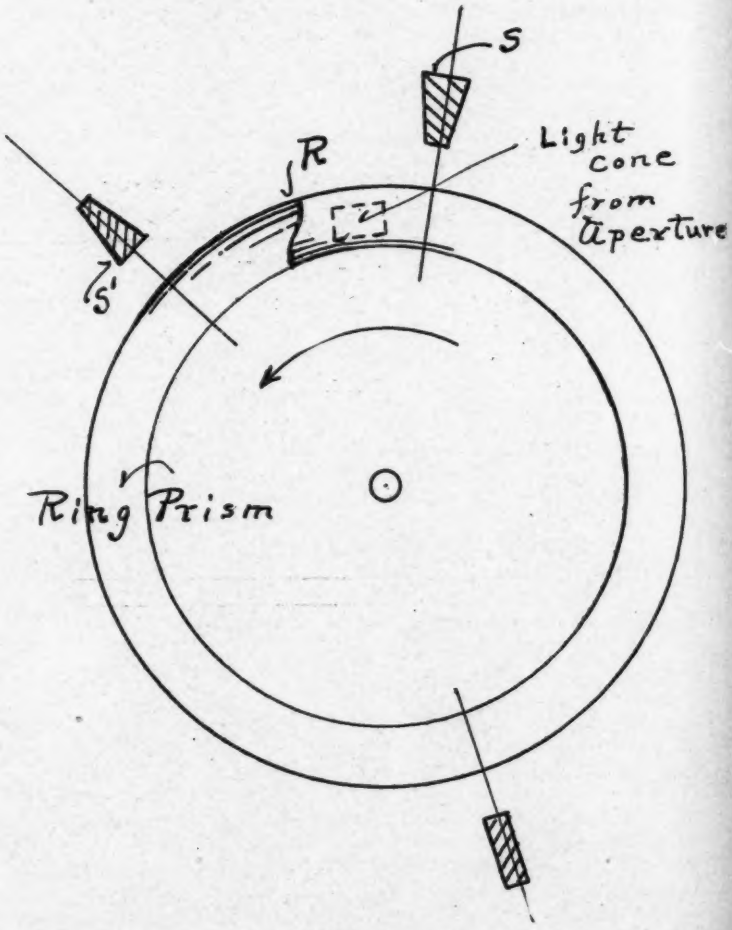


Fig. 3.

its initial position (a) at the top of the picture aperture; and finally with its base down (S′, Fig. 1) to project the ray to its final position (b) at the bottom of the aperture, that is, the end of the down-

ward travel of the film. Obviously at the moment the ray passes the middle of the aperture it is not bent at all, and, therefore, the "prism" cannot be a prism at this point but only a plain parallel-sided piece of glass.

The light ray acts as though it were hinged at the location of the prism. If, therefore, we could make a solid glass prism and endow it with the ability to automatically change the angle of its faces in synchronism wth the movement of the film, the ray of light or the picture-carrying cone of light would follow the film, which is exactly the object we seek.

Such an assumption seems paradoxical, but it may be accomplished by employing a long strip of glass prism section with the base up at one end and base down at the other end and a gradually changing contour from end to end between these two extremes.

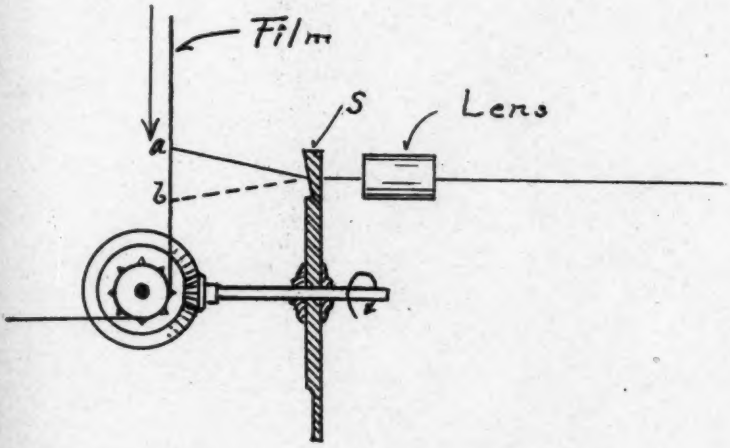


Fig. 4.

(See Fig. 2.) If this strip of glass is passed across the path of the film, in the light cone and in synchronism with the travel of the film, the constantly running film will appear stationary on the screen when used as a projector.

But to make the continuous motion machine of these elements the strip of prismatic glass must be made into a ring (in the plane of its width) with the two ends abutting. When this is done, the contacting ends (R, Fig. 3) represent crossed prisms, one with the base (S) outward and the other with the base (S′) toward the axis of rotation of this ring.

As a matter of convenience in fabrication, this ring prism is actually ground in the face of a disc of glass, as you will observe,

for this then makes its own support on the rotating shaft, upon which it is mounted.

This ring is so geared to the film-feeding sprocket that it makes one revolution with the passage of each single frame across the aperture, and, of course, in exact synchronism therewith. The median line of the prismatic ring, the objective, the picture aperture, and the light source are all located in the axis of the cone of light, the prism being located at the point where the hinging or bending of the light cone is to be effected.

As explained above, the ring makes one complete revolution for the passing of each picture frame, and in synchronism therewith, each frame instantaneously dissolving into the next as the joint in the prism ring crosses the light cone, so that the picture on the screen is stationary, continuous in action and without interruption by shutter blades.

Observe that the machine employs standard film, stock objectives and condensers, and the usual light source, all readily changeable as to size, focus, etc. However, as noted, it does not have the usual fifty-fifty rotating shutter necessary on the intermittent machine, and so the incandescent lamp may be expected to have still further usefulness for there is 100% increase in screen lighting efficiencies.

It is not my intention to suggest that the problem is solved to an extent precluding further improvement, but I do think any work along this line is worth while. Certainly the curious fact that no marked change in projecting machines has been made in twenty-five years would seem to warrant the assumption that there is abundant opportunity for research work.

Further Measurements of Illumination in Motion-Picture Projection

By W. E. Story, Jr.

SYNOPSIS—The method previously described has been improved and applied to the measurement of the total illumination obtained on the screen with different source sizes and different condenser systems compared to the maximum obtainable with the given source brilliancy and given objective diameters. A comparison of the photoelectric measurements with the measurements obtained using an optical photometer for condensers of different absorption and sources of two slightly different brilliancies shows the ratio of the photoelectric cell readings to the photometer readings to be independent of color thru the range considered. Uniformity of screen illumination is also taken up in a general way by the application of direct observation of the screen to the automatically drawn curves registering total illumination.

Since the work described in the last transactions of this Society, new photoelectric cells have been made that are better adapted to the measurements required. Some minor changes have also been made in the rest of the apparatus.

It has been found advisable to substitute a condensing lens for the ground glass immediately beyond the dummy objective. This condenser focuses the film aperture in the window of the cell, thus delivering all the light (barring certain constant losses of reflection and absorption) that falls on the objective to the cell instead of but a small part as did the opal glass. This change has resulted in a reasonably large galvanometer deflection, even when using an opal source as small as two-tenths of an inch square. The new arrangement offers the great advantage of a source the size of which can be changed at will, without change of any other characteristic.

To find the ratio of deflection to light received by the cell, an arrangement was used somewhat different from that previously employed. The condenser was removed from the optical bench as before, but this time the aperture plate was left in the system and covered with a piece of opal glass. If the opal glass is a perfect diffuser, the intensity of the illumination at any point beyond it will be inversely proportional to the square of the distance from the source of illumination to the opal glass, and accordingly by varying the distances and obtaining corresponding galvanometer deflections, the ratio of cell illumination to galvanometer deflection can be tested.

Figure 1 shows a plate made in this way, using a 2½-inch and 1½-inch objective with potentials of 67, 130 and 320 volts on the cell. Unfortunately, the curve made with the 2½-inch objective and 67 volts overlaps the 1½-inch objective—320-volt curve. Where the deflection is very small, a slight variation of the galvanometer zero or error of measurement has, of course, a great effect on the product of the deflection by the square of the distance. The constancy of this product, however, was well within any accuracy we could use in this work. Below is given a table show-

ing the deflections at the various distances for the six curves and the resulting products.

Fig. 2

Volts on Cell		67				130				320			
Objective		2½"		1½"		2½"		1½"		2½"		1½"	
Dist.	(Dist.)2	Defl. (Dist.)2		Defl. (Dist)2		Defl. (Dist)2		Defl. (Dist)2		Defl. (Dist)2		Defl. (Dist)2	
9	81	2.35	190.	.87	70 5	3.52	285.	1.345	109.	6.50	326.		
10	100	1.89	189.	.695	69.5	2.84	284.	1.075	107.5	5.22	522.	1.935	193.
11	121	1.57	190.	.57	69.	2 35	284.	.885	107.	4.33	524.	1.625	196.
12	144	1.32	190.	.48	69.	1.98	285.	.740	107.	3.63	524.	1.35	194.
13	169	1.12	189.	.41	69.	1.69	286.	.62	105.	3.10	525.	1.145	194.
14	196	.96	188.	.35	69.	1.45	284.	.525	103.	2.66	522.	.99	194.
15	225	.835	187.	.31	70.	1.26	284.	.46	103.	2.315	521.	.855	192.
16	256	.745	190.	.265	68.	1.105	282.	.39	100.	2.035	521.	.75	192.
17	289	.655	187.	.24	70.	.99	286.	.35	105.	1.795	518.	.665	192.
18	324	.595	191.	.215	70.	.98	287.	.32	104.	1.69	525.	.595	193.
19	361	.535	190.	.195	71.	.875	285.	.285	103.	1.45	523.	.53	191.
20	400	.48	192.	.175	70.	.715	286.	.255	102.	1.30	520.	.47	188.
21	441	.44	190.	.155	68.4	.65	286.	.235	104.	1.185	522.	.425	188.
22	484	.39	189.	.14	68.	.60	290.	.21	103.	1.08	523.	.385	187.
23	529	.365	193.	.13	69.	.55	291.	.20	106.	.90	524.	.36	191.
24	576	.34	196.	.12	69.	.50	288.	.185	106.	.905	521.	.335	193.
25	625	.31	194.	.11	69.	.465	290.	.17	106.	.84	525.		
Average			190.		69.		286.		105.		522.		192.
Ratio of Aver.		$\frac{190}{69.} = 2.75$				$\frac{286}{105} = 2.73$				$\frac{522}{192} = 2.72$			

It will be noticed that there is no tendency for the product to be higher at one end of the curve than at the other. This indicates that the deflection is proportional to the light entering the cell for a given objective size. Since the aperture is focused at the cell window and not on the potassium surface, the area of the potassium lighted will depend on the diameter of the objective. Accordingly, it remains now to find out whether the law of proportionality holds for objectives of different size, for a difference in sensitivity of different parts of the potassium surface would introduce an error into the measurements.

If it is a perfect diffuser, the opal glass covering the film aperture amounts to a source at the aperture and of its size, supplying light to the objective. Now whereas the exact quantity of light supplied an objective by such a source is quite difficult to calculate, it is very easy to find limiting values between which the true value must lie. A source of infinite size will supply to the objective a quantity of light proportional to its area.

$$Q' = AD^2$$

Where A is a constant depending upon the source brilliancy, and D the diameter of the objective.

A very small source will supply an amount

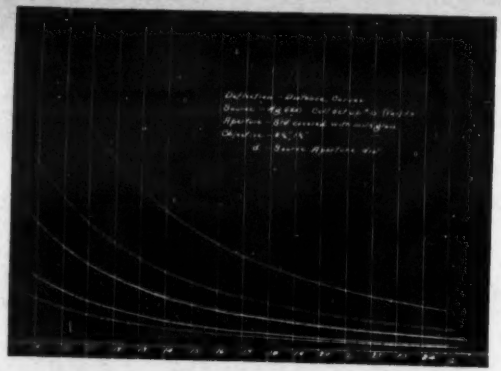
$$Q'' = B\left(1 - \frac{a}{\sqrt{a^2 + \frac{D^2}{4}}}\right)$$

where B depends on the source brilliancy and a is its distance from the objective. The ratio of the amounts supplied to objectives of different diameters will then be in the first case,

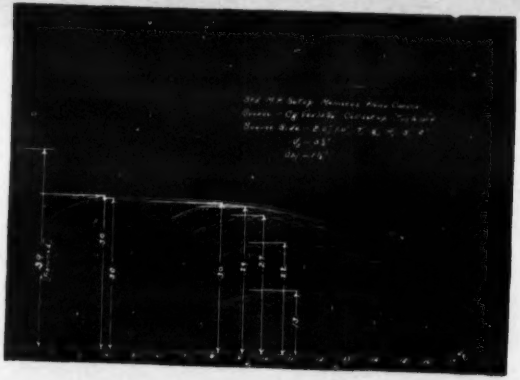
$$\frac{Q'_1}{Q'_2} = \frac{D^2_1}{D^2_2}$$

and if we are comparing the 1½-inch diameter objective with the 2½-inch we get

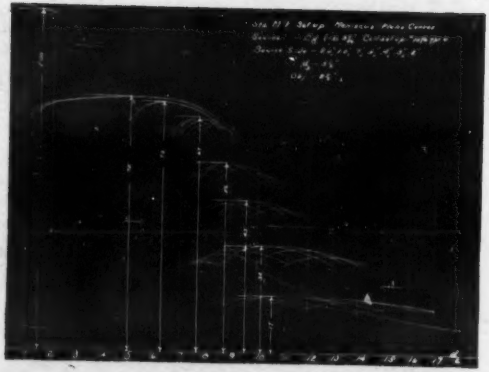
$$\frac{Q'_1}{Q'_2} = \frac{25}{9} = 2.78$$



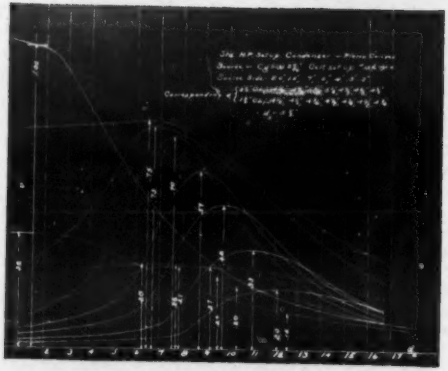
Left: Fig. 1



Right: Fig.4



Left: Fig. 3



Right: Fig. 6

In the second case by inserting the value of 5½ for both a_1 and a_2 and 2½ and 1½ for D_1 and D_2.

$$\frac{Q''_1}{Q''_2} = 2.71$$

The ratio of the actual light falling on the 2½-inch objective from the opal glass at the film aperture, to that falling on the 1½-inch objective, at 5½ inches is then less than 2.78 and more than 2.70. Since the distances in the table are the same for objectives of both sizes their average deflection ratio is the same as the ratio of the averages of their product columns. The last line of the table shows this ratio of the average for the three different cell potentials to be in good agreement and to lie within the predicted range. This means that the galvanometer deflection is proportional to the quantity of light entering the cell, regardless of the size of objective used—at least within the range treated in the present paper. Since the light entering the cell is the same as the light delivered to the objective, except for the constant proportion lost at the condenser in front of the cell, the deflection, and so the ordinates of the plates, do truly represent the quantity of light delivered to the objective by the rest of the system. The amount of this light that will be delivered to the screen by an objective of the diameter considered depends only on its reflection and absorption losses, which in turn depend on the type of lens and to a negligible degree only, on its size.

In making plates to determine simply the quantity of light, the 2½-inch dummy objective was inserted and the source was first set at .2-inch square. A value of d_1 near the best value was then chosen and with this d_1 the part of the d_2 — deflection curve in the neighborhood of the maximum was run, the maximum deflection of this curve being noted. The d_1 was then increased by one-quarter of an inch (or in the case of the prismatic condensers, where the d_1 was small, by one-eighth of an inch.) A section of this d_2 deflection curve was run and the maximum noted, and so on until the noted maxima showed a decided falling off for the successive steps. The value of d_1 was then decreased from the original value in steps until the maxima again showed the falling off. The source was then changed to a .3-inch square and the procedure repeated: then to .4-inch, .5-inch, .7-inch, 1.0-inch and finally 2.0 inches on a side. With this last source size d_1 proved to have a great range of values within which there was very little change in the maximum light, although a considerable difference in the range of d_2 for which the light was approximately constant. This plate for the meniscus plano convex condenser is shown in Fig. 3 as an example.

The 2½-inch objective was then replaced by the 1½-inch objective and similar curves made (Fig. 4). In the case of the plano convex condenser it was found necessary to lift the cell potential in steps for sources above .4-inch, in order to avoid the confusion due to the overlapping of so many curves.

Since the maximum light that we can ever get through the

aperture to the objective is that which would fall on it if the entire angle of view through the aperture from every point on the objective were filled with the source, there can be obtained, by removing the condenser entirely and using a source larger than the aperture and very close to it, a deflection on the plate corresponding to what may be called the "Maximum Theoretical Limit" of the condenser. To find this value on each plate a curve was run without condenser, using a source 2.0" square. For this curve the d_2 represents the distance from the source to the aperture plate. Starting at a low value for large values of d_2, the deflection increases at first approximately as the square of d_2 decreases, but when finally the aperture approaches close to the opal glass the curve flattens out almost parallel to the d_2 axis. We should expect this end of the curve to be a straight line and meet the deflection axis at right angles, but in the plates this was not the case, probably because of the slight falling off of the intensity of the illumination at the edges of the opal glass source, and of its failure to scatter the light uniformly in all directions. This accounts, too, for the failure of the Maximum Theoretical Limit to increase as rapidly as does the objective area. The deflection at a distance of 1½ inches was chosen as an approximate value of the theoretical limit for the size of objective considered. This value, when using a 2½-inch objective, was marked unity on the plates, and the deflection of other points in proportion.

For each of the condensers, a plate was then made having a curve for both sizes of objectives, and each size of source, using that value of d_1 which the previous plates had shown to give the highest maximum. These plates are shown in Figs. 5, 6, 7 and 8 for the meniscus plano convex, double plano convex and two prismatic condensers No. 2 and No. 3. Of these No. 2 is a slightly yellow prismatic in common use and No. 3 a new design made in whiter glass. The slight variations in the values of the maxima of corresponding curves are probably due to differences in the centering of the optical apparatus, as it was found quite difficult to keep rigidly constant positions involving the many freedoms necessary for the great flexibility required. Below is given a summary of the maximum deflections for various source sizes for the condenser systems so far tried.

Source	Objective	Plano Convex	Meniscus	Prismatic No. 2	Prismatic No. 3
.2"	2½	.20	.18	.26	.24
	1½	.12	.12	.17	.16
.3"	2½	.33	.33	.41	.44
	1½	.20	.22	.21	.24
.4"	2½	.48	.46	.47	.52
	1½	.24	.26	.23	.28
.5"	2½	.58	.58	.51	.61
	1½	.27	.28	.25	.30
.7"	2½	.70	.72	.65	.71
	1½	.27	.28	.30	.32
1.0"	2½	.73	.75	.80	.81
	1½	.28	.29	.30	.32
2.0"	2½	.75	.78	.80	.84
	1½	.28	.29	.31	.33

Fig. 9

If we consider the energy necessary to heat a source to a given temperature as approximately proportional to its area, we can plot a curve for each condenser indicating the relation of light delivered to energy expended. Such curves are shown in Fig. 10. It will be seen from these curves that the gain of illumination is slight for sources larger than .5-inch for the 1½-inch objective and .7-inch for the 2½-inch objective as long as any condenser is used. Considering the difference in type between the condensers, the equality of the light supplied the objective is remarkable.

Fig. 11 shows the curves for a half inch source with different values of d_1 when using objectives 1¾ inches, 2 inches and 2¼ inches in diameter, as well as the 2½ inches and 1½ inches in connection with the plano convex condensers. The ordinate .59 was assumed from Fig. 6, and the others measured from this.

As was pointed out in the first paper, a strict comparison of the light coming from different sources or passing through different media is impossible by the use of a photoelectric cell alone, since the sensibility—wave-length curve of the cell and the eye are not the same, and since light measurement in projection means measurement of the effect of the light on the eye. To determine the correction that must be applied to the photoelectric cell readings, due to selective absorption in the condensers, the following method was employed.

After setting up the first three condenser systems in some position of which the ordinate was known in terms of the theoretical limit, ten measurements of the light falling on the objective were taken with an optical photometer and then ten measurements of the theoretical limit. These measurements are shown in Fig. 12. As indicated each set was made with two different potentials on the source lamp (125 and 110 volts), i. e., two colors of opal glass source. The low potentials corresponds to a temperature of about 2650°K and upper to about 2770°K. Since the highest temperature at present used in an incandescent filament is about 3250°K and the arc crater 4000°K, this range of 120° will indicate but roughly what allowance must be made in the comparison of the different condensers by the cell method, though much of the violet light given off by the arc is absorbed by the glass of the lenses.

The fact that the ratio of light transmitted to the theoretical limit is higher with a higher source temperature for the prismatic No. 2 and for the meniscus, would seem to point to an absorption of the long wave lengths and a corresponding greenish tint to the condensers. This was true for the menicus, but the prismatic was yellow, rather than green and should then perhaps not have shown this tendency. The difference is slight in any case.

In the last column are given the corresponding deflections taken from Figs 7, 5 and 6. These were made at a source temperature of about 2680°K. As has been said, prismatic No. 2 had a slightly yellow tinge. This would give it a slightly higher value to the eye than to the photoelectric cell. This is shown in the table. The other two condensers are so nearly alike by the two methods that it would seem unnecessary to use an optical check on the cell at all

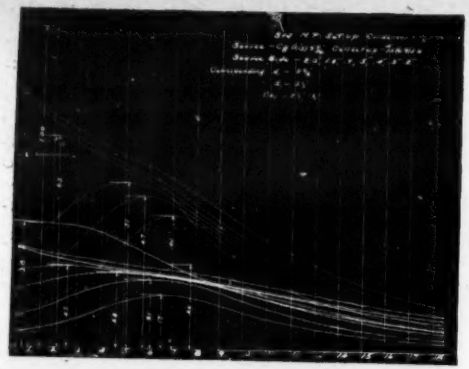


Fig. 7.

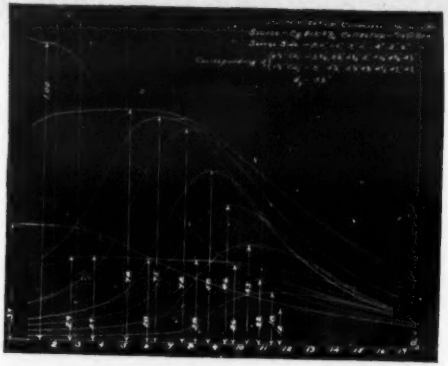


Fig. 5.

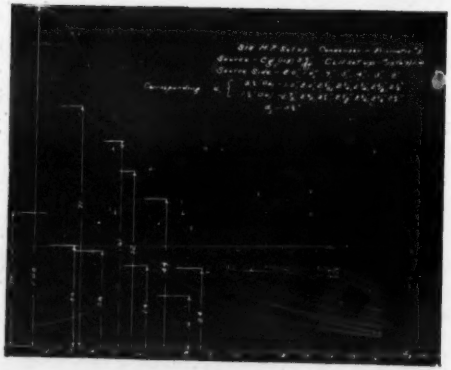


Fig. 8.

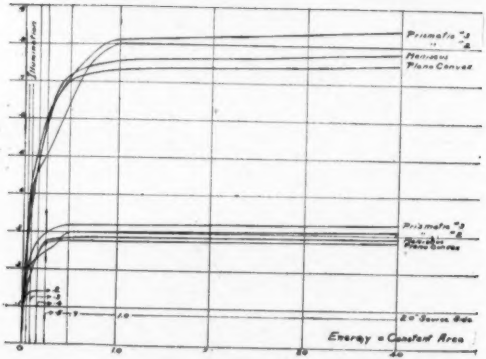


Fig. 10.

as long as the condenser exhibits no yellow color. A caution must be voiced, however, along this line, for color, or lack of color, in glass may be due to absorption in two or more regions of the spectrum, and so may lead to error in the comparison unless an optical check is made in each case. With the condensers used in the present tests, the readings were considered close enough to justify the adoption of those given by the cell as representing the effect on the eye, with a slight reservation in favor of prismatic No. 2.

Fig. 12

COMPARISON OF PHOTO ELECTRIC CELL CURVES WITH PHOTOMETER READINGS.

Source Side	Volts	d_1	d_2	Amp.	Photometer Readings					Av.	Light with Cond. Theoretical Limit Photometer	Cell
					Prismatic Condenser No. 2							
½"	125	2⅝	5⅛	.35	1.89	1.96	1.90	1.94	2.0	1.93	.55	
					1.92	1.90	1.96	1.90	1.95			
					Theoretical Limit							
2"	125			.35	3.43	3.75	3.50	3.80	3.40	3.51		
					3.55	3.35	3.50	3.20	3.60			
					Prismatic Condenser No. 2							
½"	110	2⅝	5⅛	.35	1.45	1.15	1.14	1.10	1.19	1.18	.52	.51
					Theoretical Limit							
2"	110			.35	2.35	2.25	2.15	2.15	2.25	2.26		
					2.26	2.45	2.35	2.15	2.30			
					Meniscus Condenser							
½"	125	5	8¼	.35	2.15	2.10	2.20	2.05	2.15	2.15	.602	
					2.05	2.15	2.30	2.20	2.15			
					Theoretical Limit							
2"	125			.35	3.45	3.72	3.50	3.70	3.65	3.57		
					3.10	3.80	3.85	3.60	3.30			
					Meniscus Condenser							
½"	110	5	8¼	.35	1.18	1.30	1.22	1.34	1.24	1.33	.584	.58
					1.32	1.26	1.34	1.27	1.23			
					Theoretical Limit							
2"	110			.35	2.30	2.25	2.35	2.35	2.20	2.28		
					2.15	2.35	2.30	2.20	2.35			
					Plano Convex Condenser							
½"	125	5⅛	8¼	.36	1.79	1.72	1.84	1.79	1.76	1.79	.594	.59
					1.90	1.77	1.77	1.78	1.81			
					Theoretical Limit							
2"	125			.36	2.95	3.15	2.8	3.0	2.8	3.01		
					3.15	3.0	3.1	2.95	3.2			
					Plano Convex Condenser							
½"	110	5⅛	8¼	.36	1.08	1.05	1.07	1.15	1.06			
					1.07	1.05	1.05	1.07	1.05	1.07	.594	.59
					Theoretical Limit							
2"	110			.36	1.78	1.91	1.80	1.72	1.84	1.81		
					1.86	1.80	1.80	1.75	1.80			

Motion-picture projection does not concern itself with the total quantity of light alone. Uniformity of screen illumination is also a factor. Five plates were made as a basis of curves showing uniformity. Fig. 13 shows two families of curves made with a plano convex condenser, one with a 2½-inch and the other with a 1¾-inch dummy objective. Each family consists of curves differing in d_1 as before. The maximum ordinate of the upper family has been assumed as .59 from Fig. 6 and the others calculated from their proportional lengths. Figs 14 and 15 are the same kind of curves made with prismatic No. 2 and prismatic No. 3, although, of course, with different actual values of d_1. These three plates were made with an opal glass source .5-inch on a side which is approximately equivalent in area and uniformity to the crater of a direct-current arc of 110 amperes, and in area to the 900-watt incandescent filament lamp. Figs. 16 and 17 were made with plano convex and prismatic No. 3 condenser respectively, and .3-inch source, equivalent to a 33-ampere arc.

To determine what part of each of the curves could be used

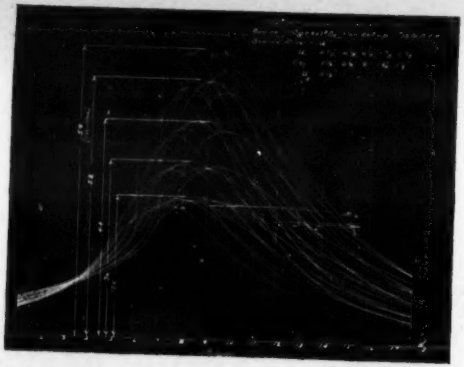


Fig. 11.

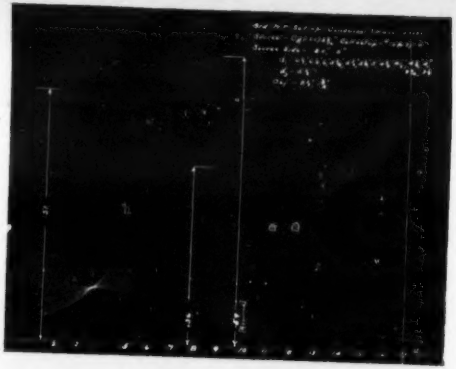


Fig. 13.

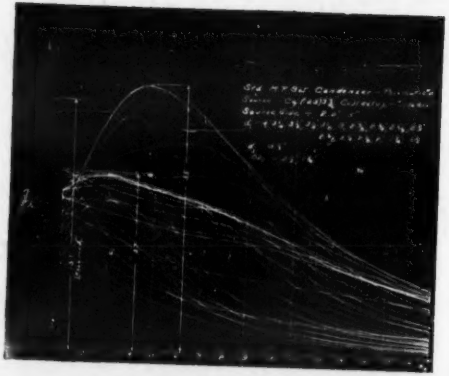


Fig. 14.

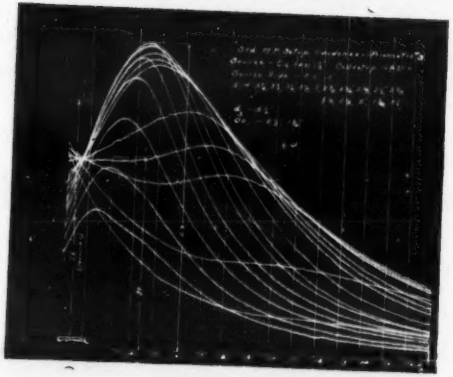


Fig. 15.

in projection without an un-uniformity of illumination on the screen, the dummy objective was replaced by a real objective lens, and the image of the aperture thrown on the screen. The objectives at hand were $2\frac{1}{16}$-inch effective diameter, 5½-inch equivalent focus, and 1½-inch diameter, 4-inch focus. The latter is of about the same speed as a 1¾-inch diameter, 5½-inch focus, and will give approximately the same total illumination curves. It was because this 4-inch equivalent focus lens was the only small diameter lens at hand that the second dummy objective used in the curve was 1¾ inches in diameter, instead of 1½ inches as previously.

With opal glass .3 inch and .5 inch square, and a 900-watt incandescent filament lamp as sources, with each of these objectives and with each of the three condensers, and each of the d_1 used in Figs. 13 to 17, d_2 was varied and the uniformity of illumination of the screen carefully observed. For each arrangement, the range of values of d_2 for which the screen showed the following characteristics was noted:

ILLUMINATION	NOTATION				
1. Uniformity					
2. Dark center	o	o	o	o	o
3. Dark corners	.	.	.	.	.
4. Black corners	—	—	—	—	—
5. Streaks	I	I	I	I	I
6. Image of the Source	II	II	II	II	II

Of these the last two were noticeable only when using the incandescent filament. Of course, these observations involving as they do merely the appearance of uniformity, though not being at all accurate—as shown by the many inconsistencies of the readings of d_2—are nevertheless exactly the kind of observations that affect practical projection.

Tracings were next made from the plates, of representative curves of each source size, condenser and objective combination and the different parts of each curve drawn in the appropriate symbol or symbols, where several kinds of un-uniformity overlapped. Tracings for the 900-watt incandescent filament lamp were made, of course, from the plates taken with a .5/10-inch source, the symbols being determined by observation of the screen as described above. Some of these tracings are shown in Figs. 18-24. The objectives are called 2½-inch and 1¾-inch in these figures, but they were really, as has been pointed out, 2½-inch diameter, 5½-inch focus and 1½-inch diameter, 4-inch focus.

Figs. 18 and 19 show the distribution for different values of d_1 when the plano convex and prismatic No. 3 condensers are used with a .3-inch source. The subscript "a" refers to the 2½-inch objective and "b" to the 1¾-inch objective. Figs. 20 and 21 give the same condensers with a .5″ source. These curves show the gain in uniformity as well as brightness when the larger source is used. Figs. 22 and 23 taken in connection with the last plates show the effect of the coils of the incandescent filament on screen uniformity with the different condensing systems. Fig. 24 shows the same thing using prismatic No. 2.

It is apparent from Figs. 18 to 21 that with sources of uniform

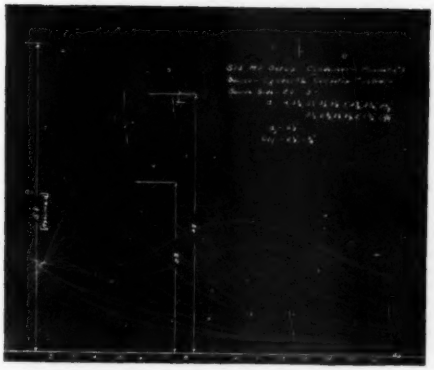


Fig. 16.

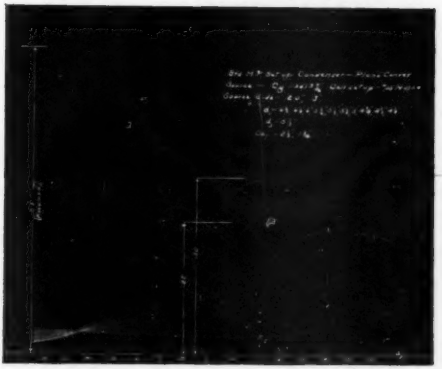


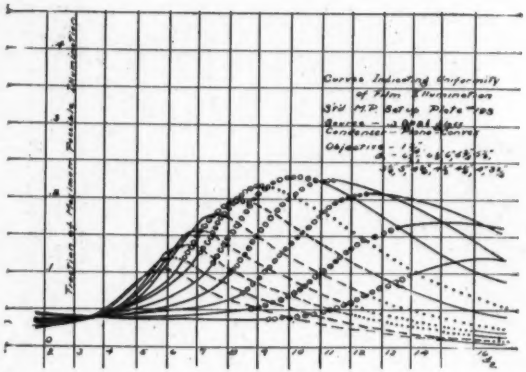
Fig. 17.

brilliancy, such as an arc crater, the value of condenser efficiency in actual projection can be as high as those given in Fig. 9, but from Figs. 22 to 24, it is evident that when using the 900-watt motion-picture lamp, the illumination that can be obtained with a uniform screen is less than the maximum illumination represented by the tops of these curves. Fig. 25 shows the reductions with plano convex and the two prismatic condensers for 2½-inch and 1¾-inch objectives.

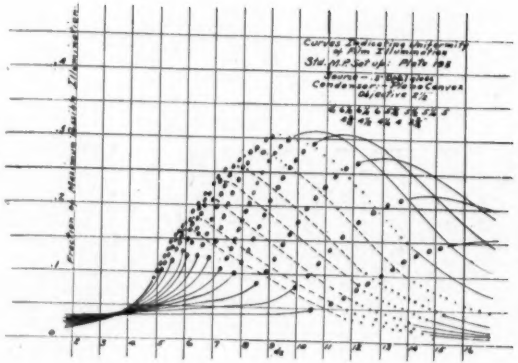
Fig. 25

	Plano Convex		Prismatic No. 2		Prismatic No. 3	
Condenser Objective	2½"	1¾"	2½"	1¾"	2½"	1¾"
Max. Illumination	.59	.37	.56	.35	.61	.38
Max. Uniform Illumination	.28	.30	.45	.11	.58	.38

These figures show the great gain in uniform illumination, with an un-uniform source, made possible by the use of a condenser, such as the prismatic, which does not give a true image. The very low value with prismatic No. 2, when used with a small objective, is



Left
Fig. 18a.



Right
Fig. 18b.

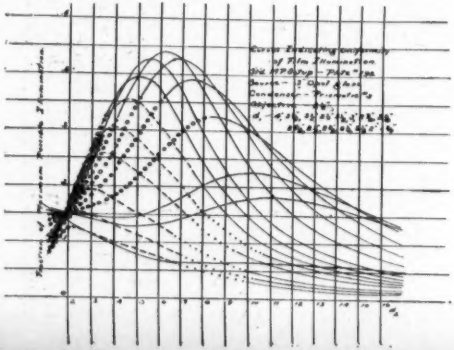


Fig. 19a.

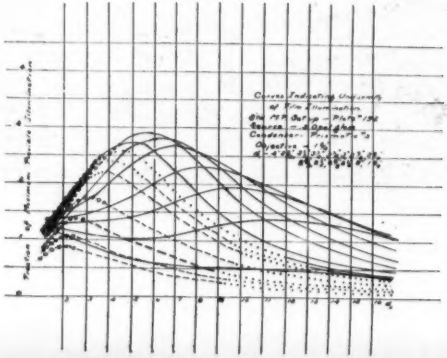


Fig. 19b.

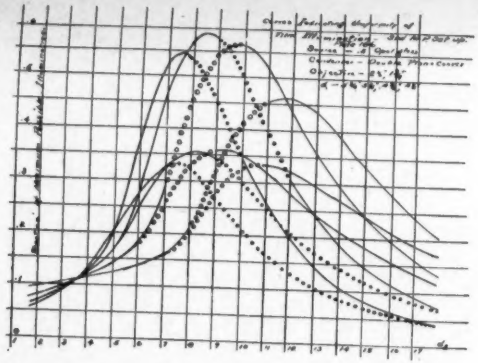


Fig. 20.

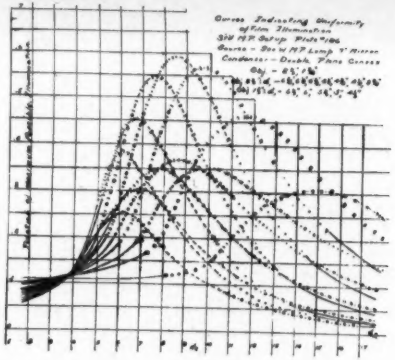


Fig. 22.

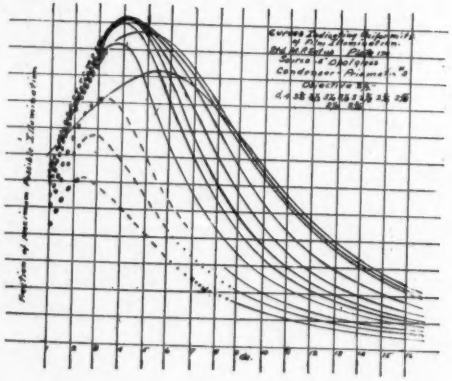


Fig. 21a.

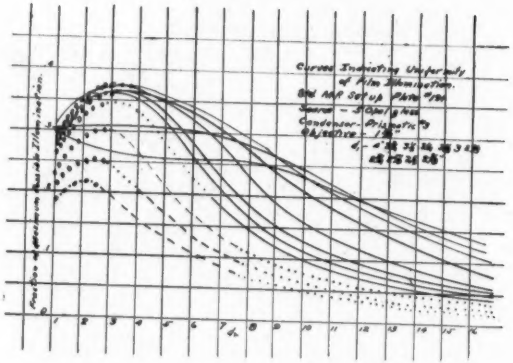


Fig. 21b.

due to the preponderance of light coming through its center, which is a simple lens. Prismatic No. 3 has been designed to break up the filament images more than does No. 2. The result of this is a great extension of the uniform range. It is evident that though the larger objective gives more light in all three cases, it does not, when used with the plano convex condenser, give appreciably more light in the uniform range.

SUMMARY

The results obtained so far may be summarized as follows:

1. The photoelectric cell can be made to give readings, closely proportional to the total illumination, as measured by an optical photometer, delivered to an objective of any size, and for any differences of color normally met in practice.

2. There is no material gain in illumination for any of the condenser systems tried, by the use of a source larger than .7-inch on a side for a 2½-inch objective or .5-inch for a 1½-inch objective.

3. There is not more than 10 per cent. difference in the maximum total illumination given by any of the types of condensers when used with a source .4-inch or over.

4. For sources as large as .4-inch with any of the condensers tried, there is delivered to the 2½-inch objective at least twice as much light as to the 1½-inch.

5. Uniformity of illumination accompanies maximum illumination for all the condensers and objectives considered when used with uniform sources having an area as great as .3-inch square. On the other hand, for the 900-watt motion-picture lamp, although the prismatic condenser No. 3, when used with a 1¾-inch objective gives a maximum illumination that is uniform, when used with a 2½-inch objective, the greatest uniform illumination is 6 per cent. below the maximum. The plano convex condenser requires a decrease of 20 per cent. to obtain uniformity with the 1¾-inch objective and over 50 per cent. with the 2½-inch objective, whereas uniform illumination can be obtained with prismatic No. 2 only by a sacrifice of 69 per cent. with 1½-inch objective though with a 2½-inch objective of but 20 per cent.

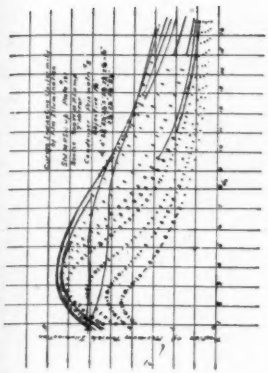


Fig. 23b.

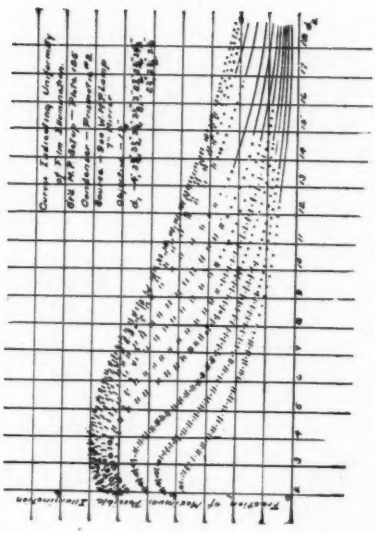


Fig. 24b.

Fig. 23a.

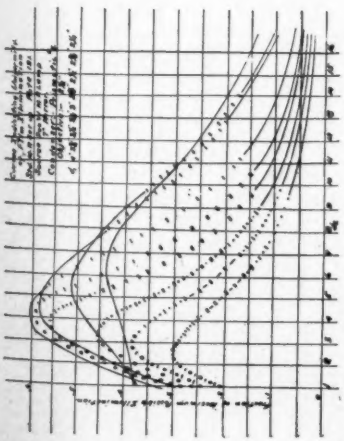
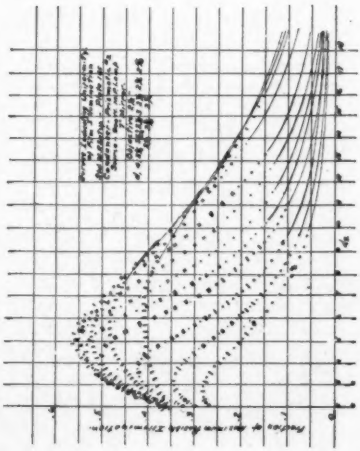


Fig. 24a.



Report of the Optics Committee

Since the last meeting of the society, your Committee on Optics has had three meetings to determine, if possible, the effect on an optience of tint in a motion picture. Unfortunately, due to the wide scattering of the committee, at no meeting have there been more than four members present. In spite of this, however, the committee has at least made a start toward collecting the data required of it. This report then it but a preliminary one showing results already obtained and pointing the way to a large field of most interesting investigation in the future.

In the first place, it was thought color could affect the picture on the screen in five ways. The apparent brightness may be affected. The clearness. The contrast. Then again color may improve the naturalness of the picture. For example, a blue tint for the sea, a red tint for a burning building, etc. The fifth way is in the effect of color on the mood. These last two ways the committee has, for the time being, disregarded as belonging to the psychological rather than the physiological phase of the subject, and so a question for the producer rather than the engineer.

At the first meeting of the committee, March 23rd, a general method of approaching the problem was decided upon. It would seem that screens that would absorb part of the spectrum, when illuminated with white light (i. e., tinted screens) could be assumed to give identical effects on the eye, as white screens illuminated by light from which the same part of the spectrum had been absorbed by some interposed filter. Accordingly, considerations of convenience led to the adoption for the tests at hand of white screens and of white light, from which different colors had been absorbed. The only way of comparing colors accurately was thought to be the observing of a picture in each color thrown simultaneously on the screen side by side. A request was then sent the Eastman Kodak Co. for a number of short lengths from the same film (i. e., all the lengths printed and finished from the same negative film under the same conditions), each length to be dyed different color. These were very kindly furnished the committee. Each length was then fastened in a loop so that it could be run through a machine continuously.

While these films were in the course of preparation, some crude preliminary experiments were made at a meeting on April 13th. These tests consisted in running a loop of untinted film through a machine and observing the effect of interposing a number of tinted gelatine filters (furnished by the Bausch & Lomb Co.) in the light beam in front of the objective. It was found, as had been expected, that it was impossible to remember the characteristics of a previous color well enough to compare it with the color on the screen, except in cases of extreme difference. So extreme did these differences have to be that the committee almost despaired of arriving at any helpful conclusions.

When the tinted films arrived the facilities of the Cinema

Quipment Center in New York were generously put at the disposal of the Committee for the test. Two arc projectors, similar in all respects, were arranged to throw two pictures, side by side, on a single white beaded screen, and the optience (from 5 to 8 in number) sat in the line between the two pictures. Both arcs were maintained, as nearly as possible, at 60 amperes and 50 volts throughout the tests. To each person were given slips of papers having spaces for checking his preference of the two pictures on the screen in respect to brightness, clearness and contrast. With light beams intercepted, the untinted loop of film was put in one machine and a tinted loop in the other. The room lights were turned off and then the two pictures thrown on the screen. It was originally planned for each observer to note his first impression of the relative brightness, clearness and contrast of the two pictures and then after examining the pictures for two minutes, to note again in separate columns his final decision. It was found, however, that it took so long to form any definite opinion that the pictures were run for one-half minute and judged on the final decision alone. After this half-minute run, the light beams were cut off and the room lights turned on in order that the eyes of the optience might regain their original sensitiveness.

A thin metal disc, having holes all over it ¼ inch between centers, and of such a size that just one-half of the disc area was cut away (i. e.,, hole .2 inch in diameter) was placed in the front of the objective throwing the untinted picture. A second test was now made and judged as before. Then a third with a disc having one-quarter of its area cut away (.141 inch holes), and a fourth with one-eighth (.1 inch holes) cut away. These discs, of course, reduced the quantity of light from the untinted film to one-half, one-quarter and one-eighth of its original value respectively, while the tinted picture remained unchanged.

The results of tnese tests are given in the table. Only a decided majority of votes was considered as an indication of difference. It was quite astonishing, however, to find how closely the opinions coincided in the great majority of cases. The colors tried were:

Pale rose, pale carmine, deep red and deep carmine.

Pale amber, pale yellow, pale lemon, lemon and deep amber.

Very pale green, pale blue green, pale olive, grass green and deep green.

Pale blue, blue, deep blue, red blue, very red blue, deep purple and deep violet.

Perhaps the most striking thing shown by the table is that the pale yellow and pale green give the appearance of equal or greater brightness, though, of course, having less energy delivered to the screen by the amount absorbed in the dye on the film. This effect was so marked that in the case of the pale amber, the films and machines were interchanged with results that checked with the previous test. Of equal interest is the fact that the contrast was invariably increased by pale colors, and the clearness as well, with the exception of pale blue, pale blue green, pale olive and pale car-

mine. Deep blue and deep purple reduce apparent contrast. The purple gave a picture on which it was noticeably hard to focus the eyes satisfactorily. Pale carmine was the first tint run and it afterwards developed that some of the judges had not understood the system on this first color, and through an oversight, this was not run again. This probably accounts for its eccentric behavior.

I. UNTINTED LIGHT UNREDUCED

		Brightness	SUMMARY		
INCREASE	NO EFFECT	DECREASE	INCREASE	NO EFFECT	DECREASE
Pale	Pale Yellow	All others	1	3	17
Amber	Pale Lemon				
	Very Pale Green				
		Clearness			
{Very red / Blue}	Pale blue	Blue	6	6	9
		Grass green			
Pale rose	Red blue	Deep blue			
		Deep blue green			
Pale amber	Deep carmine	Deep purple			
Pale yellow	Deep amber	Deep violet			
	{Pale blue / green}	Deep red			
Pale lemon					
{Very pale / green}	Pale olive	Pale carmine			
		Lemon			
		Contrast			
All others	Blue	Deep blue			
	Red blue	Deep purple	14	5	2
	Deep violet				
	Deep red				
	Deep blue green				

II. UNTINTED LIGHT REDUCED TO ½

			SUMMARY		
INCREASE	NO EFFECT	DECREASE	INCREASE	NO EFFECT	DECREASE
		Brightness			
Red blue	Pale blue	Very red blue			
Pale carmine	Pale rose	Blue			
Deep red	Deep carmine	Deep blue			
Pale amber	Pale olive	Deep purple			
Pale yellow		Deep violet	9	4	8
Pale lemon		Grass green			
Lemon		Pale blue green			
Deep amber		Deep blue green			
Very pale green					
		Clearness			
All others	Deep violet	Deep blue			
		Deep purple			
		Deep blue green	17	1	3
		Contrast			
	Deep blue	Deep purple	19	1	1

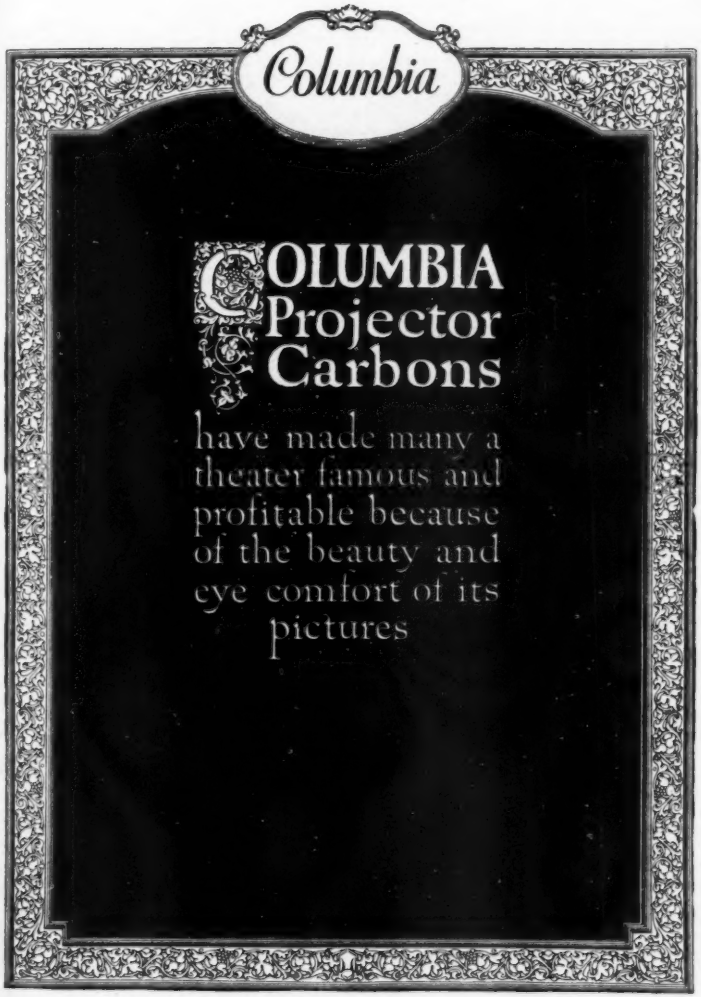
III. UNTINTED LIGHT REDUCED TO ¼

			SUMMARY		
INCREASE	NO EFFECT	DECREASE	INCREASE	NO EFFECT	DECREASE
		Brightness			
All others	Deep blue	Deep purple			
	Pale carmine		17	3	1
	Deep blue green				
		Clearness			
All others	Deep blue	Deep purple			
	Pale carmine		10	2	1
		Contrast			
All others	Pale carmine	Deep purple	19	1	1

IV. UNTINTED LIGHT REDUCED TO ⅛

			SUMMARY		
INCREASE	NO EFFECT	DECREASE	INCREASE	NO EFFECT	DECREASE
		Brightness			
	Pale carmine		20	1	0
		Clearness			
	Pale carmine	Deep purple	19	1	1
		Contrast			
	Pale carmine				

The above results are not complete, as the committee has not yet been able to determine the quantity of light absorbed by the dye, and accordingly the ratio between the actual energy passing through the tinted and untinted films. When this is known, it is expected that the advantage of tints will be still more strongly marked. The committee hopes to have this information by the next meeting of the society.



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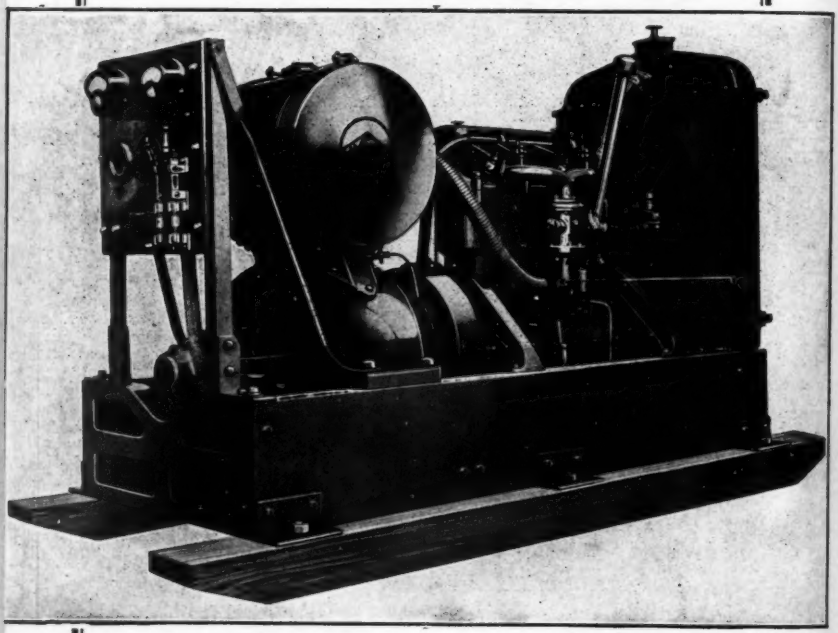

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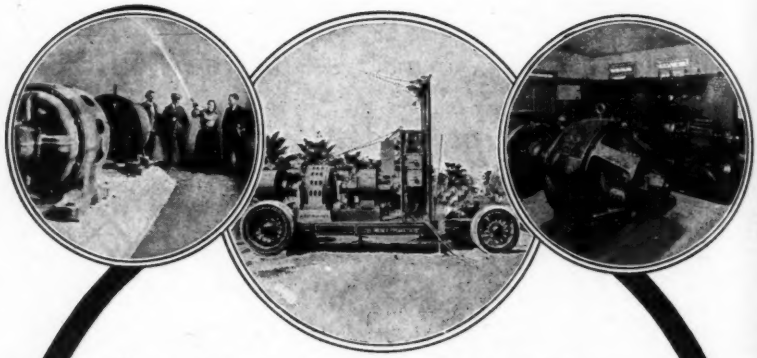

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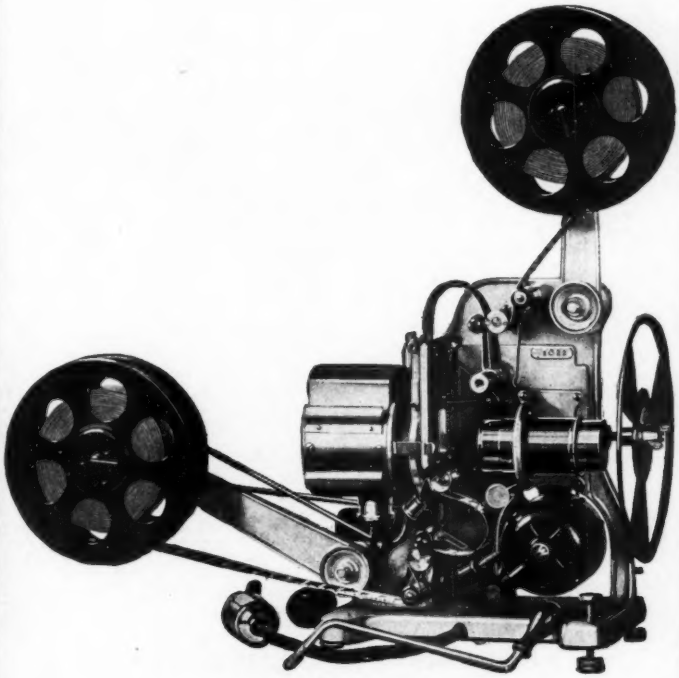

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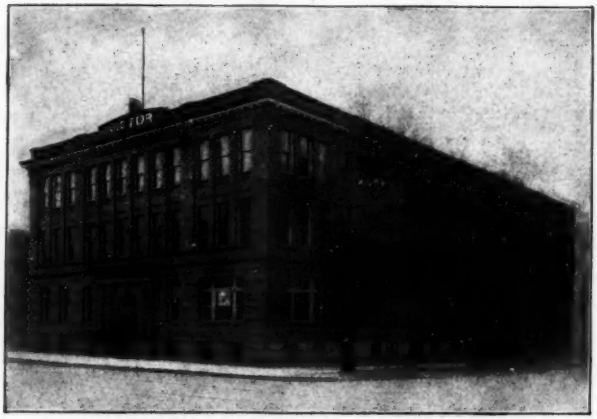

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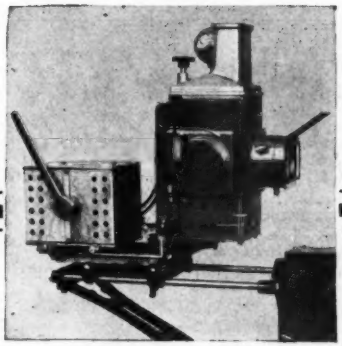

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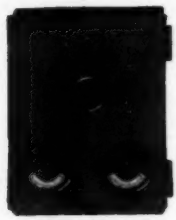

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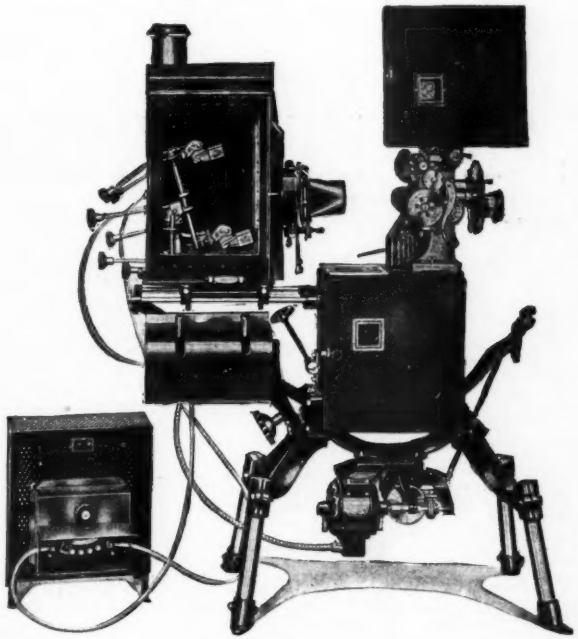

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